Patent
Attorney's Docket No. 012712-792

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

REQUEST FOR FILING CONTINUATION/DIVISIONAL APPLICATION UNDER 37 C.F.R. § 1.53(b)

Box PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

This is a request for filing a [ ] continuation [X] divisional application under 37 C.F.R. § 1.53(b) of pending Application No. 08/487,550 filed on June 7, 1995, for HUMAN B7.1-SPECIFIC PRIMATIZED ANTIBODIES AND TRANSFECTOMAS EXPRESSING SAID ANTIBODIES, by the following named inventor(s):

(a) Full Name Darrell R. ANDERSON
(b) Full Name Peter BRAMS
(c) Full Name Nabil HANNA
(d) Full Name Bill SHESTOWSKY
(e) Full Name Cheryl HEARD

[X] The entire disclosure of the prior application from which a copy of the oath or declaration is supplied herewith is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

[ ] This application is being filed by less than all the inventors named in the prior application. In accordance with 37 C.F.R. 1.63(d)(2), the Commissioner is requested to delete the name(s) of the following person or persons who are not inventors of the invention being claimed in this application.

(a) Full Name _____
(b) Full Name _____
(c) Full Name _____

1. [X] Enclosed is a copy of the prior Application No. 08/487,550 as originally filed on June 7, 1995, including copies of the specification, claims, drawings and the executed oath or declaration as filed.

2. [ ] Enclosed is a revised prior application and a copy of the prior executed oath or declaration as filed. No new matter has been added to the revised application.

3. [X] One statement(s) claiming small entity status [ ] are enclosed [X] were filed in prior Application No. 08/487,550, filed on June 7, 1995.

4. [X] The filing fee is calculated below [X] and in accordance with the enclosed preliminary amendment:

CLAIMS	NO. OF CLAIMS		EXTRA CLAIMS	RATE	FEE
Basic Application Fee					$760.00
Total Claims	6	MINUS 20 =	0	x $18.00 =	0.00
Independent Claims	1	MINUS 3 =	0	x $78.00 =	0.00
If multiple dependent claims are presented, add $260.00					0.00
Total Application Fee					760.00
If small entity status is claimed, subtract 50% of Total Application Fee					380.00
Add Assignment Recording Fee of $40.00 if Assignment document is enclosed					0.00
TOTAL APPLICATION FEE DUE					380.00

5. [ ] Charge $ _____ to Deposit Account No. 02-4800 for the fee due.

6. [X] A check in the amount of $ 380.00 is enclosed for the fee due.

7. [X] The Commissioner is hereby authorized to charge any appropriate fees under 37 C.F.R. §§ 1.16, 1.17 and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800. This paper is submitted in triplicate.

8. [X] Cancel in this application original claims 2-15 of the prior application before calculating the filing fee. (At least one original independent claim must be retained for filing purposes.)

9. [X] Amend the specification by inserting before the first line the sentence: --This application is a [ ] continuation, [X] divisional, of Application No. 08/487,550, filed June 7, 1995.--

10. [ ] Transfer the drawings from the pending prior application to this application and abandon said prior application as of the filing date accorded this application. A duplicate of this paper is

enclosed for filing in the prior application file. (May only be used if signed by person authorized under 37 C.F.R. § 1.138 and before payment of issue fee.)

11. [X] New drawings are enclosed.

12. [ ] Priority of Application No. __ filed on _ in __ (country) is claimed under 35 U.S.C. § 119.

[ ] The certified copy of the priority application
[ ] is enclosed
[ ] was filed on __ in prior Application No. __, filed on __
[ ] has not yet been filed.

13. [X] A preliminary amendment is enclosed.

14. [X] Also enclosed Request for Listing of References Considered by Examiner and Statement Pursuant to 37 C.F.R. 1.822.

15. [X] The power of attorney in the prior application is to E. Joseph Gess .

a. [X] The power appears in the original papers in the prior application.

b. [ ] Since the power does not appear in the original papers, a copy of the power in the prior application is enclosed.

c. [X] Recognize as Associate Attorney Robin L. Teskin, Reg. No. 35,030 .

d. [X] Address all future communications to: (May only be completed by applicant, or attorney or agent of record.)

E. Joseph Gess
BURNS, DOANE, SWECKER & MATHIS, L.L.P.
P.O. Box 1404
Alexandria, Virginia 22313-1404

August 26, 1999
Date

By: 
Robin L. Teskin
Registration No. 35,030

ADDRESS OF
SIGNATOR:

BURNS, DOANE, SWECKER & MATHIS, L.L.P.
P.O. Box 1404
Alexandria, Virginia 22313-1404
(703) 836-6620

[ ] inventor(s)
[ ] assignee of complete interest
[ ] attorney or agent of record
[X] filed under 37 C.F.R. § 1.34(a)

COPY

Patent
Attorney's Docket No. 012712-131

Applicant or Patentee: Darrell R. ANDERSON et al

Application or Patent No.: 08/487,550

Filed or Issued: June 7, 1995

For: MONKEY MONOCLONAL ANTIBODIES SPECIFIC TO HUMAN B7.1 AND/OR B7.2 PRIMATIZED FORMS THEREOF, PHARMACEUTICAL COMPOSITIONS CONTAINING, AND USE THEREOF AS IMMUNOSUPPRESSANTS

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 C.F.R. §§ 1.9(f) AND 1.27(c)) - SMALL BUSINESS CONCERN

I hereby declare that I am

[ ] the owner of the small business concern identified below:
[X] an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN IDEC Pharmaceuticals Corporation

ADDRESS OF CONCERN 11011 Torrevana Road

San Diego, CA 92121

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 C.F.R. § 121.12, and reproduced in 37 C.F.R. § 1.9(d), for purposes of paying reduced fees under Sections 41(a) and 41(b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average, over the previous fiscal year of the concern, of the persons employed on a full-time, part-time, or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention entitled MONKEY MONOCLONAL ANTIBODIES SPECIFIC TO HUMAN B7.1 AND/OR B7.2 PRIMATIZED FORMS THEREOF, PHARMACEUTICAL COMPOSITIONS CONTAINING, AND USE THEREOF AS IMMUNOSUPPRESSANTS by inventor(s) Darrell R. ANDERSON, Peter BRAMS, Nabil HANNA, and Bill SHESTOWSKY , described in

[ ] the specification filed herewith
[X] Application No. 08/487,550, filed June 7, 1995
[ ] Patent No. _____, issued _____.

If the rights held by the above-identified small business concern are not exclusive, each individual, concern, or organization having rights to the invention is listed below,* and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 C.F.R. § 1.9(c), or by any concern that would not qualify as either a small business concern under 37 C.F.R. § 1.9(d) or a nonprofit organization under 37 C.F.R. § 1.9(e).

*NOTE: Separate verified statements are required from each named person, concern, or organization having rights to the invention averring to their status as small entities. (37 C.F.R. § 1.27.)

NAME _____

ADDRESS _____

[ ] individual [ ] small business concern [ ] nonprofit organization

NAME _____

ADDRESS _____

[ ] individual [ ] small business concern [ ] nonprofit organization

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earlier of the issue fee and any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 C.F.R. § 1.28(b).)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code; and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING Kenneth J. Woolcott

TITLE OF PERSON OTHER THAN OWNER Vice President, General Counsel & Licensing Exec.

ADDRESS OF PERSON SIGNING 11011 Torrevana Road, San Diego, CA 92121

SIGNATURE _____ DATE 11/21/95

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	)
	)
Darrell R. ANDERSON et al.	) Group Art Unit: Unassigned
	)
Application No. Unassigned	) Examiner: Unassigned
	)
Filed: August 26, 1999	)
	)
For: HUMAN B7.1-SPECIFIC PRIMATIZED ANTIBODIES AND TRANSFECTOMAS EXPRESSING SAID ANTIBODIES	)

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination, please first amend the above-identified application as follows:

IN THE SPECIFICATION

Insert pages 59 to 80, containing the sequence listing for the subject application, and renumber the subsequent pages accordingly.

Page 21, line 1, delete "8a" and insert --8A-1 and 8A-2 (SEQ ID NOS:1-2)--;

Page 21, line 4, delete "8b" and insert --8B-1, 8B-2 and 8B-3 (SEQ ID NOS:3-4)--;

Page 21, line 7, delete "9a" and insert --9A-1 and 9A-2 (SEQ ID NOS:5-6)--;

Page 21, line 9, delete "9b" and insert --9B-1, 9B-2 and 9B-3 (SEQ ID NOS:7-8)--;

Page 21, line 11, delete "10a" and insert --10A-1 and 10A-2 (SEQ ID NOS:9-10)--; and

Page 21, line 13, delete "10b" and insert --10B-1, 10B-2 and 10B-3 (SEQ ID NOS:11-12)--.

IN THE CLAIMS

Claim 16, last line, please delete "any one of claims 1 to 11" and insert therefor --claim 1--.

REMARKS

Favorable consideration on the merits is respectfully requested.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS, L.L.P.

By: _____
Robin L. Teskin
Registration No. 35,030

P.O. Box 1404
Alexandria, Virginia 22313-1404
(703) 836-6620

Date: August 26, 1999

TITLE OF THE INVENTION

MONKEY MONOCLONAL ANTIBODIES SPECIFIC TO HUMAN B7.1 AND/OR B7.2, PRIMATIZED FORMS THEREOF, PHARMACEUTICAL COMPOSITIONS CONTAINING, AND USE THEREOF AS IMMUNOSUPPRESSANTS

RELATED APPLICATIONS

There are no related applications.

FIELD OF THE INVENTION

The present invention relates to the manufacture and identification of novel monoclonal antibodies to human B7, i.e., human B7.1 and human B7.2 and primatized forms thereof. More specifically, the present invention relates to the production and identification of macaque antibodies to human B7, i.e., human B7.1 and human B7.2 produced by screening of phage display libraries and monkey heterohybridomas using B lymphocytes obtained from B7 immunized monkeys.

The invention further relates to specific primatized antibodies which bind to human B7, i.e., human B7.1 and B7.2 as well as their corresponding amino acid and nucleic acid sequences.

Also, the present invention relates to pharmaceutical compositions containing monkey monoclonal or primatized antibodies specific to human B7.1 and/or human B7.2 and their use as immunosuppressants by modulating the B7:CD28 pathway, e.g., for the treatment of autoimmune disorders, and the prevention of organ rejection.

BACKGROUND OF THE INVENTION

The clinical interface between immunology, hematology, and oncology has long been appreciated.

Many conditions treated by the hematologist or oncologist have either an autoimmune or immunodeficient component to their pathophysiology that has led to the widespread adoption of immunosuppressive medications by hematologists, whereas oncologists have sought immunologic adjuvants that might enhance endogenous immunity to tumors. To date, these interventions have generally consisted of nonspecific modes of immunosuppression and immune stimulation. In addition to the limited efficacy of these interventions, toxicities secondary to their nonspecificity have also limited their overall success. Therefore, alternative strategies have been sought.

Elucidation of the functional role of a rapidly increasing number of cell surface molecules has contributed greatly to the integration of immunology with clinical hematology and oncology. Nearly 200 cell surface antigens have been identified on cells of the immune and hematopoietic systems (Schlossman SF. Boumsell L. Gilks JM, Harlan T. Kishimoto, C. Morimoto C, Ritz J. Shaw S, Silverstein RL, Springer TA, Tedder TF, Todd RF:CD antigens (1993), Blood 83:879, 1994). These antigens represent both lineage-restricted and more widely distributed molecules involved in a variety of processes, including cellular recognition, adhesion, induction and maintenance of proliferation, cytokine secretion, effector function, and even cell death. Recognition of the functional attributes of these molecules has fostered novel attempts to manipulate the immune response. Although molecules involved in cellular adhesion and antigen-specific recognition have previously been evaluated as targets of therapeutic immunologic intervention, recent attention has focused on a subgroup of cell surface molecules termed co-

stimulatory molecules (Bretscher P: "The two-signal model of lymphocyte activation twenty-one years later." Immunol. Today 13:73, (1992); Jenkins MK, Johnson JG: "Molecules involved in T-cell co-stimulation." Curr Opin Immunol 5:351, 1993; Geppert T, Davis L. Gur H. Wacholtz M. Lipsky P: "Accessory cell signals involved in T-cell activation." Immunol Rev 117:5, (1990); Weaver CT, Unanue ER: "The co-stimulatory function of antigen-presenting cells." Immunol Today 11:49, (1990); Stennam RM, Young JW: "Signals arising from antigen-presenting cells." Curr Opin Immunol 3:361, (1991)). Co-stimulatory molecules do not initiate but rather enable the generation and amplification of antigen-specific T-cell responses and effector function (Bretscher P: "The two-signal model of lymphocyte activation twenty-one years later." Immunol. Today 13:73, (1992); Jenkins MK, Johnson JG: "Molecules involved in T-cell co-stimulation." Curr Opin Immunol 5:351, (1993); Geppert T, Davis L. Gur H. Wacholtz M. Lipsky P: "Accessory cell signals involved in T-cell activation." Immunol Rev 117:5, (1990); Weaver CT, Unanue ER: "The co-stimulatory function of antigen-presenting cells." Immunol Today 11:49, (1990); Stennam RM, Young JW: "Signals arising from antigen-presenting cells." Curr Opin Immunol 3:361, (1991); June CH, Bluestone JA, Linsley PS, Thompson CD: "Role of the CD28 receptor in T-cell activation." Immunol Today 15:321, (1994).

Recently, one specific co-stimulatory pathway termed B7:CD28 has been studied by different research groups because of its significant role in B and T cell activation (June CH, Bluestone JA, Linsley PS, Thompson CD: "Role of the CD28 receptor in T-cell activation." Immunol Today 15:321, (1994); June CH, Ledbetter JA:

"The role of the CD28 receptor during T-cell responses to antigen." Annu Rev Immunol 11:191, (1993); Schwartz RH: "Co-stimulation of T lymphocytes: The role of CD28, CTLA-4, and B7/BB1 in interleukin-2 production and immunotherapy." Cell 71:1065, (1992)). Since this ligand:receptor pathway was discovered four years ago, a large body of evidence has accumulated suggesting that B7:CD28 interactions represent one of the critical junctures in determining immune reactivity versus anergy (June CH, Bluestone JA, Linsley PS, Thompson CD: "Role of the CD28 receptor in T-cell activation." Immunol Today 15:321, (1994); June CH, Ledbetter JA: "The role of the CD28 receptor during T-cell responses to antigen." Annu Rev Immunol 11:191, (1993); Schwartz RH: "Co-stimulation of T lymphocytes: The role of CD28, CTLA-4, and B7/BB1 in interleukin-2 production and immunotherapy." Cell 71:1065, (1992); Cohen J: "Mounting a targeted strike on unwanted immune responses" (news; comment). Science 257:751, (1992); Cohen J: "New protein steals the show as 'co-stimulator' of T cells" (news; comment). Science 262:844, (1993)).

In particular, the role of the human B7 antigens, i.e., human B7.1 and B7.2, has been reported to play a co-stimulatory role in T-cell activation.

1. B7.1 and B7.2 Co-stimulatory Role in T Cell Activation

The elaboration of a successful immune response depends on a series of specific interactions between a T cell and an antigen presenting cell. Although the essential first step in this process depends upon the binding of antigen to the T cell receptor, in the context of the MHC class II molecule (Lane, P.J.L., F.M. McConnell, G.L. Schieven, E.A. Clark, and J.A.

Ledbetter, (1990), "The Role of Class II Molecules in Human B Cell Activation." The Journal of Immunology, 144:3684-3692), this interaction alone is not sufficient to induce all the events necessary for a sustained response to a given antigen (Schwartz, R.H. (1990), "A Cell Culture Model for T Lymphocyte Clonal Anergy." Science, 248:1349; Jenkins, M.K. (1992). "The Role of Cell Division in the Induction of Clonal Anergy." Immunology Today, 13:69; Azuma, M., M. Catabyab, D. Buck, J.H. Phillips, and L.L. Lanier, (1992). "Involvement of CD28 in MHC-unrestricted Cytotoxicity Mediated by a Human Natural Killer Leukemia Cell Line." The Journal of Immunology, 149:1556-1561; Azuma, M., M. Catabyab, D. Buck, J.H. Phillips, and L.L. Lanier, (1992). "CD28 Interaction with B7 Costimulates Primary Allogeneic Proliferative Responses and Cytotoxicity Mediated by Small Resting T Lymphocytes." J. Exp. Med., 175:353-360).

The involvement of certain other co-stimulatory molecules is necessary (Norton, S.D., L. Zuckerman, K.B. Urdahl, R. Shefner, J. Miller, and M.K. Jenkins. (1992), "The CD28 Ligand, B7, Enhances IL-2 Production by Providing A Costimulatory Signal to T Cells." The Journal of Immunology, 149:1556-1561). "The homodimers CD28 and CTLA-4 expressed on T cells" (June, C.H., J.A. Ledbetter, P.S. Linsley, and C.B. Thompson, (1990), "Role of the CD28 Receptor in T-Cell Activation." Immunology Today, 11:211-216; Linsley, P.S., W. Brady, M. Urnes, L.S. Grosmaire, N.K. Damle, and J.A. Ledbetter, (1991), "CTLA-4 is a Second Receptor for the B Cell Activation Antigen B7." J. Exp. Med., 174:561), together with B7.1 (CD80) and B7.2 (CD86) expressed on antigen presenting cells, are major pairs of co-stimulatory molecules necessary for a sustained immune

response (Azuma, M., H. Yssel, J.H. Phillips, H. Spits, and L.L. Lanier, (1993), "Functional Expression of B7/BB1 on Activated T Lymphocytes." J. Exp. Med., 177:845-850; Freeman, G.J., A.S. Freedman, J.M. Segil, G. Lee, J.F. Whitman, and LM. Nadler, (1989), "B7, A New Member of the Ig Superfamily with Unique Expression on Activated and Neoplastic B Cells." The Journal of Immunology, 143:2714-2722; Hathcock, K.S., G. Laslo, H.B. Dickler, J. Bradshaw, P. Linsley, and R.J. Hodes, (1993), "Identification of an Alternative CTLA-4 Ligand Costimulatory for T Cell Activation." Science, 262:905-911; Hart, D.N.J., G.C. Starling, V.L. Calder, and N.S. Fernando, (1993). "B7/BB-1 is a Leucocyte Differentiation Antigen on Human Dendritic Cells Induced by Activation." Immunology, 79:616-620). It can be shown *in vitro* that the absence of these co-stimulatory signals leads to an aborted T cell activation pathway and the development of unresponsiveness to the specific antigen, or anergy. (*See*, e.g., Harding, F.A., J.G. McArthur, J.A. Gross, D.M. Raulet, and J.P. Allison, (1992). "CD28 Mediated Signalling Co-sbmulates Murine T Cells and Prevents Induction of Anergy in T Cell Clones." Nature, 356:607-609; Gimmi, C.D., G.J. Freeman, J.G. Gribben, G. Gray, and L.M. Nadler, (1993). "Human T-Cell Clonal Anergy is Induced by Antigen Presentation in the Absence of B7 Costimulation." Proc. Natl. Acad. Sci., 90:6586-6590; Tan, P., C. Anasefti, J.A. Hansen, J. Melrose, M. Brunvand, J. Bradshaw, J.A. Ledbetter, and P.S. Linsley, (1993), "Induction of Alloantigen-specific Hyporesponsiveness in Human T Lymphocytes by Blocking Interaction of CD28 with Its Natural Ligand B7/BB1." J. Exp. Med., 177:165-173). Achievement of *in vivo* tolerance constitutes a mechanism for immunosuppression and a viable therapy for organ

transplant rejection and for the treatment of autoimmune diseases. This has been achieved in experimental models following the administration of CTLA4-Ig (Lenschow, D.J., Y. Zeng, R.J. Thistlethwaite, A. Montag, W. Brady, M.G. Gibson, P.S. Linsley, and J.A. Bluestone, (1992), "Long-Term Survival of Xenogeneic Pancreatic Islet Grafts Induced by CTLA-4Ig." Science, 257:789-795).

The molecules B7.1 and B7.2 can bind to either CD28 or CTLA-4, although B7.1 binds to CD28 with a Kd of 200 Nm and to CTLA-4 with a 20-fold higher affinity (Linsley, P.S., E.A. Clark, and J.A. Ledbetter, (1990), "T-Cell Antigen CD28 Mediates Adhesion with B Cells by Interacting with Activation Antigen B7/BB-1." Proc. Natl. Acad. Sci., 87:5031-5035; Linsley et al, (1993), "The Role of the CD28 receptor during T cell responses to antigen," Annu. Rev. Immunol., 11:191-192; Linesley et al, (1993), "CD28 Engagement by B7/BB-1 Induces Transient Down-Regulation of CD28 Synthesis and Prolonged Unresponsiveness to CD28 Signaling," The Journal of Immunology, 150:3151-3169). B7.2 is expressed on activated B cells and interferon induced monocytes, but not resting B cells (Freeman, G.J., G.S. Gray, C.D. Gimmi, D.B. Lomarrd, L-J. Zhou, M. White, J.D. Fingeroth, J.G. Gribben, and LM. Nadler, (1991). "Structure, Expression and T Cell Costimulatory Activity of the Murine Homologue of the Human B Lymphocyte Activation Antigen B7," J. Exp. Med., 174:625-631). B7.2, on the other hand, is constitutively expressed at very low levels on resting monocytes, dendritic cells and B cells, and its expression is enhanced on activated T cells, NK cells and B lymphocytes (Azuma, M. D. Ito, H. Yagita, K. Okumura, J.H. Phillips, L.L. Lanier, and C. Somoza, "1993", "B70 Antigen is a Second Ligand for CTLA-4 and CD28," Nature, 366:76-79). Although B7.1

and B7.2 can be expressed on the same cell type, their expression on B cells occurs with different kinetics (Lenschow, D.J., G.H. Su, L.A. Zuckerman, N. Nabavi, C.L. Jellis, G.S. Gray, J. Miller, and J.A. Bluestone, (1993), "Expression and Functional Significance of an Additional Ligand for CTLA-4," Proc. Natl. Acad. Sci., USA, 90:11054-11058; Boussiotis, V.A., G.J. Freeman, J.G. Gribben, J. Daley, G. Gray, and L.M. Nadler, (1993), "Activated Human B Lymphocytes Express Three CTLA-4 Counter-receptors that Co-stimulate T-Cell Activation." Proc. Natl. Acad. Sci., USA, 90:11059-11063). Further analysis at the RNA level has demonstrated that B7.2 mRNA is constitutively expressed, whereas B7.1 MRNA is detected 4 hours after activation and initial low levels of B7.1 protein are not detectable until 24 hours after stimulation (Boussiotis, V.A., G.J. Freeman, J.G. Gribben, J. Daley, G. Gray, and L.M. Nadler, (1993), "Activated Human B Lymphocytes Express Three CTLA-4 Counter-receptors that Co-stimulate T-Cell Activation," Proc. Natl. Acad. Sci., USA, 90:11059-11063). CTLA-4/CD28 counter receptors, therefore, may be expressed at various times after B Cell activation.

The differential temporal expression of B7.1 and B7.2 suggests that the interaction of these two molecules with CTLA-4 and/or CD28 deliver distinct but related signals to the T cell (LaSalle, J.M., P.J. Tolentino, G.J. Freeman, L.M. Nadler, and D.A. Hafler, (1992), "CD28 and T Cell Antigen Receptor Signal Transduction Coordinately Regulate Intedeukin 2 Gene Expression In Response to Superantigen Stimulation," J. Exp. Med., 176:177-186; Vandenberghe, P., G.J. Freeman, L.M. Nadler, M.C. Fletcher, M. Kamoun, L.A. Turka, J.A. Ledbetter, C.B. Thompson, and C.H. June, (1992),

"Antibody and B7/BB1-mediated Ligation of the CD28 Receptor Induces Tyrosine Phosphorylation in Human T Cells," The Journal of Experimental Medicine, 175:951-960). The exact signaling functions of CTLA-4 and CD28 on the T cell are currently unknown (Janeway, C.A., Jr. and K. Bottomly, (1994), "Signals and Signs for Lymphocyte Responses," Cell, 76.275285). However, it is possible that one set of receptors could provide the initial stimulus for T cell activation and the second, a sustained signal to allow further elaboration of the pathway and clonal expansion to take place (Linsley, P.S., J.L. Greene, P. Tan, J. Bradshaw, J.A. Ledbetter, C. Anasetti, and N.K. Damle, (1992), "Coexpression and Functional Cooperation of CTLA-4 and CD28 on Activated T Lymphocytes," J. Exp. Med., 176:1595-1604). The current data supports the two-signal hypothesis proposed by Jenkins and Schwartz (Schwartz, R.H., (1990), "A Cell Culture Model for T Lymphocyte Clonal Anergy," Science, 248:1349; Jenkins, M.K., (1992), "The Role of Cell Division in the Induction of Clonal Anergy," Immunology Today, 13:69) that both a TCR and co-stimulatory signal are necessary for T cell expansion, lymphokine secretion and the full development of effector function (Greenan, V. and G. Kroemer, (1993), "Multiple Ways to Cellular Immune Tolerance," Immunology Today, 14:573). The failure to deliver the second signal results in the inability of T cells to secrete IL-2 and renders the cell unresponsive to antigen.

Structurally, both B7.1 and B7.2 contain extracellular immunoglobulin superfamily V and C-like domains, a hydrophobic transmembrane region and a cytoplasmic tail (Freeman, G.J., J.G. Gribben, V.A. Boussiotis, J.W. Ng, V. Restivo, Jr., L.A. Lombard, G.S.

Gray, and L.M. Nadler, (1993), "Cloning of B7-2: A CTLA-4 Counter-receptor that Co-stimulates Human T Cell Proliferation," Science, 262:909). Both B7.1 and B7.2 are heavily glycosylated. B7.1 is a 44-54kD glycoprotein comprised of a 223 amino acid extracellular domain, a 23 amino acid transmembrane domain, and a 61 amino acid cytoplasmic tail. B7.1 contains 3 potential protein kinase phosphorylation sites. (Azuma, M., H. Yssel, J.H. Phillips, H. Spits, and L.L. Lanier, (1993), "Functional Expression of B7/BB1 on Activated T Lymphocytes," J. Exp. Med., 177:845-850). B7.2 is a 306 amino acid membrane glycoprotein. It consists of a 220 amino acid extracellular region, a 23 amino acid hydrophobic transmembrane domain and a 60 amino acid cytoplasmic tail (Freeman, G.J., A.S. Freedman, J.M. Segil, G. Lee, J.F. Whitman, and LM. Nadler, (1989), "B7, A New Member of the Ig Superfamily with Unique Expression on Activated and Neoplastic B Cells," The Journal of Immunology, 143:2714-2722). Although both B7.1 and B7.2 genes are localized in the same chromosomal region (Freeman, G.J., D.B. Lombard, C.D. Gimmi, S.A. Brod, L Lee, J.C. Laning, D.A. Hafler, M.E. Dorf, G.S. Gray, H. Reiser, C.H. June, C.B. Thompson, and L.M. Nadler, (1992), "CTLA-4 and CD28 MRNA are Coexpressed in Most T Cells After Activation," The Journal of Immunology, 149:3795-3801; Schwartz, R.H., (1992), "Costimulation of T Lymphocytes: The Role of CD28, CTLA-4, and B7/BB1" in Selvakumar, A., B.K. Mohanraj, R.L. Eddy, T.B. Shows, P.C. White, C. Perrin, and B. Dupont, (1992), "Genomic Organization and Chromosomal Location of the Human Gene Encoding the B-Lymphocyte Activation Antigen B7," Immunogenetics, 36:175-181), these antigens do not share a high level of homology. The overall homology between B7.1 and B7.2 is

26% and between murine B7.1 and human S7 is 27% (Azuma, M., H. Yssel, J.H. Phillips, H. Spits, and L.L. Lanier, (1993), "Functional Expression of B7/BB1 on Activated T Lymphocytes," J. Exp. Med., 177:845-850; Freeman, G.J., A.S. Freedman, J.M. Segil, G. Lee, J.F. Whitman, and LM. Nadler, (1989), "B7, A New Member of the Ig Superfamily with Unique Expression on Activated and Neoplastic B Cells," The Journal of Immunology, 143:2714-2722). Although alignment of human B7.1 human B7.2 and murine B.1 sequences shows few stretches of lengthy homology, it is known that all three molecules bind to human CTLA-4 and CD28. Thus, there is most likely a common, or closely homologous region shared by the three molecules that may be either contiguous or conformational. This region may constitute the binding site of the B7.1 and B7.2 molecules to their counter-receptors. Antibodies raised against these epitopes could potentially inhibit the interaction of B7 with its counter-receptor on the T cell. Furthermore, antibodies that cross-reacted with this region on both B7.1 and B7.2 molecules would potentially have practical advantages over antibodies directed against B7.1 or B7.2 separately.

2. Blockade of the B7/CD28 Interaction

Blocking of the B7/CD28 interaction offers the possibility of inducing specific immunosuppression, with potential for generating long lasting antigen-specific therapeutic effects. Antibodies to either B7.1 or B7.2 have been shown to block T cell activation, as measured by the inhibition of IL-2 production *in vitro* (DeBoer, M., P. Parren, J. Dove, F. Ossendorp, G. van der Horst, and J. Reeder, (1992), "Functional Characterization of a Novel Anti-B7 Monoclonal Antibody," Eur. Journal of Immunology, 22:3071-3075; Azuma, M., H. Yssel, J.H.

Phillips, H. Spits, and L.L. Lanier, (1993), "Functional Expression of B7/BB1 on Activated T Lymphocytes," J. Exp. Med., 177:845-850). However, different antibodies have been shown to vary in their immunosuppressive potency, which may reflect either their affinity or epitope specificity. CTLA-4/lg fusion protein and anti-CD28 Fabs were shown to have similar effects on the down regulation of IL-2 production.

In vivo administration of a soluble CTLA-4/lg fusion protein has been shown to suppress T cell - dependent antibody responses in mice (Linsley, P.S., J.L. Greene, P. Tan, J. Bradshaw, J.A. Ledbetter, C. Anasetti, and N.K. Damle, (1992), "Coexpression and Functional Cooperation of CTLA-4 and CD28 on Activated T Lymphocytes," J. Exp. Med., 176:1595-1604; Lin, H., S.F. Builing, P.S. Linsley, R.O. Wei, C.D. Thompson, and L.A. Turka, (1993), "Long-term Acceptance of Major Histocompatibility Complex Mismatched Cardiac Allografts Induced by CTLA-4-Ig Plus Donor Specific Transfusion," J. Exp. Med., 178:1801) and, furthermore, larger doses were also able to suppress responses to a second immunization, demonstrating the feasibility of this approach for the treatment of antibody mediated autoimmune disease. In addition, CTLA-4/Ig was able to prevent pancreatic islet cell rejection in mice by directly inhibiting the interaction of T cells and B7.1/B7.2 antigen presenting cells (Lenschow, D.J., G.H. Su, L.A. Zuckerman, N. Nabavi, C.L. Jellis, G.S. Gray, J. Miller, and J.A. Bluestone, (1993), "Expression and Functional Significance of an Additional Ligand for CTLA-4," Proc. Natl. Acad. Sci., USA, 90:11054-11058). In this case, long term donor specific tolerance was achieved.

3. Recombinant Phage Display Technology for Antibody Selection

To date, no monoclonal antibodies which crossreact with both B7.1 and B7.2 have been reported. As noted, such antibodies would potentially be highly desirable as immunosuppressants. Phage display technology is beginning to replace traditional methods for isolating antibodies generated during the immune response, because a much greater percentage of the immune repertoire can be assessed than is possible using traditional methods. This is in part due to PEG fusion inefficiency, chromosomal instability, and the large amount of tissue culture and screening associated with heterohybridoma production. Phage display technology, by contrast, relies on molecular techniques for potentially capturing the entire repertoire of immunoglobulin genes associated with the response to a given antigen.

This technique is described by Barber et al, Proc. Natl. Acad. Sci., USA, 88, 7978-7982, (1991). Essentially, immunoglobulin heavy chain genes are PCR amplified and cloned into a vector containing the gene encoding the minor coat protein of the filamentous phage M13 in such a way that a heavy chain fusion protein is created. The heavy chain fusion protein is incorporated into the M13 phage particle together with the light chain genes as it assembles. Each recombinant phage contains, within its genome, the genes for a different antibody Fab molecule which it displays on its surface. Within these libraries, in excess of 10^6 different antibodies can be cloned and displayed. The phage library is panned on antigen coated microliter wells, non-specific phage are washed off, and antigen binding phage are eluted. The genome from the antigen-specific clones is isolated and the gene III is excised, so that

antibody can be expressed in soluble Fab form for further characterization. Once a single Fab is selected as a potential therapeutic candidate, it may easily be converted to a whole antibody. A previously described expression system for converting Fab sequences to whole antibodies is IDEC's mammalian expression vector NEOSPLA. This vector contains either human gamma 1 or gamma 4 constant region genes. CHO cells are transfected with the NEOSPLA vectors and after amplification this vector system has been reported to provide very high expression levels (> 30 pg/cell/day) can be achieved.

4. Primatized Antibodies

Another highly efficient means for generating recombinant antibodies is disclosed by Newman, (1992), Biotechnology, 10, 1455-1460. More particularly, this technique results in the generation of primatized antibodies which contain monkey variable domains and human constant sequences. This reference is incorporated by reference in its entirety herein. Moreover, this technique is also described in commonly assigned U.S. Application No. 08/379,072, filed on January 25, 1995, which is a continuation of U.S. Serial No. 07/912,292, filed July 10, 1992, which is a continuation-in-part of U.S. Serial No. 07/856,281, filed March 23, 1992, which is finally a continuation-in-part of U.S. Serial No. 07/735,064, filed July 25, 1991. 08/379,072 and the parent application thereof are incorporated by reference in their entirety herein.

This technique modifies antibodies such that they are not antigenically rejected upon administration in humans. This technique relies on immunization of cynomolgus monkeys with human antigens or receptors.

This technique was developed to create high affinity monoclonal antibodies directed to human cell surface antigens.

Antibodies generated in this manner have previously been reported to display human effector function, have reduced immunogenicity, and long serum half-life. The technology relies on the fact that despite the fact that cynomolgus monkeys are phylogenetically similar to humans, they still recognize many human proteins as foreign and therefore mount an immune response. Moreover, because the cynomolgus monkeys are phylogenetically close to humans, the antibodies generated in these monkeys have been discovered to have a high degree of amino acid homology to those produced in humans. Indeed, after sequencing macaque immunoglobulin light and heavy chain variable region genes, it was found that the sequence of each gene family was 85-98% homologous to its human counterpart (Newman et al, (1992), Id.). The first antibody generated in this way, an anti-CD4 antibody, was 91-92% homologous to the consensus sequence of human immunoglobulin framework regions. Newman et al, Biotechnology, 10:1458-1460, (1992).

Monoclonal antibodies specific to the human B7 antigen have been previously described in the literature. For example, Weyl et al, Hum. Immunol., 31(4), 271-276, (1991) describe epitope mapping of human monoclonal antibodies against HLA-B-27 using natural and mutated antigenic variants. Also, Toubert et al, Clin. Exp. Immunol., 82(1), 16-20, (1990) describe epitope mapping of an HLA-B27 monoclonal antibody that also reacts with a 35-KD bacterial outer membrane protein. Also, Valle et al, Immunol., 69(4), 531-535, (1990) describe a monoclonal antibody of the IgG1 subclass

which recognizes the B7 antigen expressed in activated B cells and HTLV-1-transformed T cells. Further, Toubert et al, J. Immunol., 141(7), 2503-9, (1988) describe epitope mapping of HLA-B27 and HLA-B7 antigens using intradomain recombinants constructed by making hybrid genes between these two alleles in *E. coli*.

High expression of B7 antigen has been correlated to autoimmune diseases by some researchers. For example, Ionesco-Tirgoviste et al, Med. Interre, 24(1), 11-17, (1986) report increased B7 antigen expression in type 1 insulin-dependent diabetes. Also, the involvement of B7 antigen expression on dermal dendritic cells obtained from psoriasis patients has been reported. (Nestle et al, J. Clin. Invest., 94(1), 202-209, (1994)).

Further, the inhibition of anti-HLA-B7 alloreactive CTL using affinity-purified soluble HLA-B7 has been reported in the literature. (Zavazava et al, Transplantation, 51(4), 838-42, (1991)). Further, the use of B7 receptor soluble ligand, CTLA-4-Ig to block B7 activity (See, e.g., Lenschow et al, Science, 257, 789, 7955 (1992)) in animal models and a B7-1-Ig fusion protein capable of inhibiting B7 has been reported.

SUMMARY AND OBJECTS OF THE INVENTION

An object of the invention is to produce and identify novel macaque antibodies to human B7 antigen, more specifically to human B7.1 antigen and/or human B7.2 antigen.

More specifically, it is an object of the present invention to produce and identify novel macaque antibodies to human B7 antigen, i.e., human B7.1 and human B7.2 antigen by screening of phage display libraries and/or monkey heterohybridomas using B

lymphocytes obtained from human B7 antigen, i.e., human B7.1 or B7.2 antigen immunized monkeys.

It is another specific object of the invention to provide anti-B7 monkey monoclonal antibodies and primatized forms thereof which specifically bind human B7.1 and/or B7.2 antigen which inhibit the B7/CD86 pathway and B7 stimulation of activated T cells, thereby inhibiting IL-2 production and T cell proliferation and functioning as effective immunosuppressants.

It is another object of the invention to provide anti-human B7.1 and anti-human B7.2 monkey monoclonal antibodies and primatized forms thereof which inhibit antigen driven responses in donor spleen cell cultures, e.g., antigen specific IgG responses, IL-2 production and cell proliferation.

It is another specific object of the invention to identify particular monkey monoclonal antibodies specific to human B7.1 and human B7.2 antigen and primatized forms thereof having advantageous properties, i.e., affinity, immunosuppressive activity, which are useful as therapeutics. More specifically, these monkey antibodies and primatized forms thereof are to be used, e.g., as immunosuppressants, i.e., to block antigen driven immune responses, to treat autoimmune diseases such as psoriasis, rheumatoid arthritis, systemic erythematosus (SLE), type 1 diabetes mellitus, idiopathic thrombocytopenia purpura (ITP), and to prevent organ rejection.

It is another object of the invention to provide pharmaceutical compositions containing one or more monkey monoclonal antibodies specific to human B7 antigen, i.e., human B7.1 and/or human B7.2 antigen, or primatized forms thereof, and a pharmaceutically acceptable carrier or excipient. These compositions

will be used, e.g., as immunosuppressants to treat autoimmune diseases, e.g., idiopathic thrombocytopenia purpura (ITP) and systemic lupus erythematosus (SLE), to block antigen driven immune responses, and to prevent organ rejection in transplant recipients.

It is another object of the invention to provide novel methods of therapy by administration of therapeutically effective amounts of one or more monkey or primatized monoclonal antibodies which specifically bind to B7 antigen, i.e., human B7.1 and/or B7.2 antigens. Such therapeutic methods are useful for treatment of diseases treatable by inhibition of the B7:CD28 pathway e.g., autoimmune diseases such as idiopathic thrombocytopenia purpura (ITP), systemic lupus erythematosus (SLE), type 1 diabetes mellitus, psoriasis, rheumatoid arthritis, multiple sclerosis, aplastic anemia, as well as for preventing rejection in transplantation subjects.

It is still another object of the invention to provide transfectants, e.g., CHO cells, which express at least the variable heavy and light domains of monkey monoclonal antibodies specific to the human B7.1 and/or B7.2 antigen.

It is another object of the invention to provide nucleic acid sequences which encode the variable heavy and/or light domains of monkey monoclonal antibodies specific to human B7.1 and/or human B7.2 antigen, and expression vectors which provide for the expression of primatized antibodies containing these nucleic acid sequences.

Definitions

The following terms are defined so that the invention may be more clearly understood.

Depleting antibody - an antibody which kills activated B cells or other antigen presenting cells.

Non-depleting antibody - an antibody which blocks the co-stimulatory action of B7 and T cell activating ligands CD28 and CTLA-4. Thus, it anergizes but does not eliminate the antigen presenting cell.

Primatized antibody - a recombinant antibody which has been engineered to contain the variable heavy and light domains of a monkey antibody, in particular, a cynomolgus monkey antibody, and which contains human constant domain sequences, preferably the human immunoglobulin gamma 1 or gamma 4 constant domain (or PE variant). The preparation of such antibodies is described in Newman et al, (1992), "Primatization of Recombinant Antibodies for Immunotherapy of Human Diseases: A Macaque/Human Chimeric Antibody Against Human CDH, Biotechnology, 10:1458-1460; also in commonly assigned 08/379,072 both of which are incorporated by reference in their entirety herein. These antibodies have been reported to exhibit a high degree of homology to human antibodies, i.e., 85-98%, display human effector functions, have reduced immunogenicity, and may exhibit high affinity to human antigens.

B7 antigens - B7 antigens in this application include, e.g., human B7, B7.1 and B7.2 antigens. These antigens bind to CD28 and/or CTLA-4. These antigens have a co-stimulatory role in T cell activation. Also, these B7 antigens all contain extracellular immunoglobulin superfamily V and C-like domains, a hydrophobic transmembrane region and a cytoplasmic tail. (*See*, Freeman et al, Science, 262:909, (1993)), and are heavily glycosylated.

Anti-B7 antibodies - Antibodies, preferably monkey monoclonal antibodies or primatized forms thereof, which

specifically bind human B7 antigens, e.g., human B7.1 and/or B7.2 antigen with a sufficient affinity to block the B7:CD28 interaction and thereby induce immunosuppression.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 depicts the pMS vector used to screen recombinant immunoglobulin libraries produced against B7 displayed on the surface of filamentous phage which contains primers based on macaque immunoglobulin sequences.

Figure 2 depicts the NEOSPLA expression vector used to express the subject primatized antibodies specific to human B7.1 antigen.

Figure 3 depicts monkey serum anti-B7.1 titers directed against cell surface B7.1 on transfected CHO cells.

Figure 4 depicts inhibition of radiolabeled sB7.1 binding by SB7.1 affinity-purified monkey antibodies in the presence of unlabeled SB7 and Mab L307.4 murine anti-B7.1.

Figure 5 depicts inhibition of binding of radiolabeled monkey 135 and L3707.4 anti-B7.1 antibodies to B7 positive human SB cells by competition with affinity-purified SB7.1.

Figure 6 depicts inhibition of radiolabeled B7-Ig binding to activated human peripheral blood T cells by competing with unlabeled SB7.1 murine anti-B7.1 (L307.4) and monkey 1127 affinity purified serum antibodies.

Figure 7 depicts inhibition of IL-2 protein in mixed lymphocyte cultures by anti-B7.1 affinity-purified monkey serum antibodies.

Figure 8a depicts the amino acid and nucleic acid sequence of a primatized form of the light chain of 7C10.

Figure 8b depicts the amino acid and nucleic acid sequence of a primatized form of the heavy chain of 7C10.

Figure 9a depicts the amino acid and nucleic acid sequence of a primatized form of the light chain of 7B6.

Figure 9b depicts the amino acid and nucleic acid sequence of a primatized form of the heavy chain of 7B6.

Figure 10a depicts the amino acid and nucleic acid sequence of a primatized light chain 16C10.

Figure 10b depicts the amino acid and nucleic acid sequence of a primatized heavy chain 16C10.

DETAILED DESCRIPTION OF THE INVENTION

As described above, the present invention relates to the manufacture of novel monkey monoclonal antibodies which specifically bind human B7.1 and/or human B7.2 antigen, as well as primatized antibodies derived therefrom. These antibodies possess high affinity to human B7.1 and/or B7.2 and therefore may be used as immunosuppressants which inhibit the B7:CD86 pathway.

Preparation of monkey monoclonal antibodies will preferably be effected by screening of phage display libraries or by preparation of monkey heterohybridomas using B lymphocytes obtained from B7 (e.g., human B7.1 and/or B7.2) immunized monkeys.

As noted, the first method for generating anti-B7 antibodies involves recombinant phage display technology. This technique is generally described *supra*.

Essentially, this will comprise synthesis of recombinant immunoglobulin libraries against B7 antigen

displayed on the surface of filamentous phage and selection of phage which secrete antibodies having high affinity to B7.1 and/or B7.2 antigen. As noted *supra*, preferably antibodies will be selected which bind to both human B7.1 and B7.2. To effect such methodology, the present inventors have created a unique library for monkey libraries which reduces the possibility of recombination and improves stability. This vector, pMS, is described in detail *infra*, and is shown in Figure 1.

Essentially, to adopt phage display for use with macaque libraries, this vector contains specific primers for PCR amplifying monkey immunoglobulin genes. These primers are based on macaque sequences obtained while developing the primatized technology and databases containing human sequences.

Suitable primers are disclosed in commonly assigned 08/379,072 incorporated by reference herein.

The second method involves the immunization of monkeys, i.e., macaques, against human B7 antigen, preferably against human B7.1 and B7.2 antigen. The inherent advantage of macaques for generation of monoclonal antibodies is discussed *supra*. In particular, such monkeys, i.e., cynomolgus monkeys, may be immunized against human antigens or receptors. Moreover, the resultant antibodies may be used to make primatized antibodies according to the methodology of Newman et al, Biotechnology, 10, 1455-1460, (1992), and Newman et al, commonly assigned U.S. Serial No. 08/379,072, filed January 25, 1995, which are incorporated by reference in their entirety.

The significant advantage of antibodies obtained from cynomolgus monkeys is that these monkeys recognize many human proteins as foreign and thereby provide for the formation of antibodies, some with high affinity to

desired human antigens, e.g., human surface proteins and cell receptors. Moreover, because they are phylogenetically close to humans, the resultant antibodies exhibit a high degree of amino acid homology to those produced in humans. As noted above, after sequencing macaque immunoglobulin light and heavy variable region genes, it was found that the sequence of each gene family was 85-88% homologous to its human counterpart (Newman et al, (1992), Id.).

Essentially, cynomolgus macaque monkeys are administered human B7 antigen, e.g., human B7.1 and/or human B7.2 antigen, B cells are isolated therefrom, e.g., lymph node biopsies are taken from the animals, and B lymphocytes are then fused with KH6/B5 (mouse x human) heteromyeloma cells using polyethylene glycol (PEG). Heterohybridomas secreting antibodies which bind human B7 antigen, e.g., human B7.1 and/or human B7.2 antigen, are then identified.

Antibodies which bind to both B7.1 and B7.2 are desirable because such antibodies potentially may be used to inhibit the interaction of B7.1 and B7.2, as well as B7 with their counter-receptors, i.e., human CTLA-4 and CD28. Antibodies against these epitopes may inhibit the interaction of both human B7.1 and human B7.2 with their counter receptors on the T cell. This may potentially provide synergistic effects.

However, antibodies which bind to only one of human B7 antigen, B7.1 antigen or B7.2 antigen, are also highly desirable because of the co-involvement of these molecules in T cell activation, clonal expansion lymphokine (IL-2) secretion, and responsiveness to antigen. Given that both human B7.1 and B7.2 bind to human CTLA-4 and CD28, it is probable that there is at least one common or homologous region (perhaps a shared

conformational epitope or epitopes) to which macaque antibodies may potentially be raised.

The present inventors elected to immunize macaques against human B7.1 antigen using recombinant soluble B7.1 antigen produced in CHO cells and purified by affinity chromatography using a L307.4-sepharose affinity column. However, the particular source of human B7 antigen, human B7.1 antigen or human B7.2 antigen is not critical, provided that it is of sufficient purity to result in a specific antibody response to the particular administered B7 antigen and potentially to other B7 antigens.

The human B7 antigen, human B7.1 antigen (also called CD80) and human B7.2 antigen (also called CD86) genes have been cloned, and sequenced, and therefore may readily be manufactured by recombinant methods.

Preferably, the administered human B7 antigen, human B7.1 antigen and/or human B7.2 antigen will be administered in soluble form, e.g., by expression of a B7, B7.1 or B7.2 gene which has its transmembrane and cytoplasmic domains removed, thereby leaving only the extracellular portion, i.e., the extracellular superfamily V and C-like domains. (*See*, e.g., Grumet et al, Hum. Immunol., 40(3), p. 228-234, 1994, which teaches expression of a soluble form of human B7, which is incorporated by reference in its entirety herein).

The macaques will be immunized with the B7, B7.1 and/or B7.2 antigen, preferably a soluble form thereof, under conditions which result in the production of antibodies specific thereto. Preferably, the soluble human B7, B7.1 or B7.2 antigen will be administered in combination with an adjuvant, e.g., Complete Freund's Adjuvant (CFA), Alum, Saponin, or other known adjuvants, as well as combinations thereof. In general, this will

require repeated immunization, e.g., by repeated injection, over several months. For example, administration of soluble B7.1 antigen was effected in adjuvant, with booster immunizations, over a 3 to 4 month period, with resultant production of serum containing antibodies which bound human B7.1 antigen.

After immunization B cells are collected, e.g., by lymph node biopsies taken from the immunized animals and B lymphocytes fused with KH6/B5 (mouse x human) heteromyeloma cells using polyethylene glycol. Methods for preparation of such heteromyelomas are known and may be found in U.S. Serial No. 08/379,072 by Newman et al, filed on January 25, 1995 and incorporated by reference herein.

Heterohybridomas which secrete antibodies which bind human B7, B7.1 and/or B7.2 are then identified. This may be effected by known techniques. For example, this may be determined by ELISA or radioimmunoassay using enzyme or radionuclide labelled human B7, B7.1 and/or B7.2 antigen.

Cell lines which secrete antibodies having the desired specificity to human B7, B7.1 and/or B7.2 antigen are then subcloned to monoclonality.

In the present invention, the inventors screened purified antibodies for their ability to bind to soluble B7.1 antigen coated plates in an ELISA assay, antigen positive B cells, and CHO transfectomas which express human B7.1 antigen on their cell surface. In addition, the antibodies were screened for their ability to block B cell/T cell interactions as measured by IL-2 production and tritiated thymidine uptake in a mixed lymphocyte reaction (MLR), with B7 binding being detected using ^{125}I-radiolabeled soluble B7.1 (SB7.1).

Also, affinity purified antibodies from macaques were tested for their reactivity against CHO transfectants which expressed B7.1/Ig fusion proteins, and against CHO cells which produced human B7.2 antigen. These results indicated that the B7.1 immune sera bound to the B7.2 transfectomas. Binding of antibodies to B7.2 antigen may be confirmed using soluble B7.2-Ig reagents. As discussed in the examples, this may be effected by producing and purifying B7.2-Ig from CHO transfectomas in sufficient quantities to prepare a B7.2-Ig-sepharose affinity column. Those antibodies which cross-react with B7.2 will bind the B7.2-Ig-sepharose column.

Cell lines which express antibodies which specifically bind to human B7 antigen, B7.1 antigen and/or B7.2 antigen are then used to clone variable domain sequences for the manufacture of primatized antibodies essentially as described in Newman et al, (1992), Id. and Newman et al, U.S. Serial No. 379,072, filed January 25, 1995, both of which are incorporated by reference herein. Essentially, this entails extraction of RNA therefrom, conversion to cDNA, and amplification thereof by PCR using Ig specific primers. Suitable primers are described in Newman et al, 1992, Id. and in U.S. Serial No. 379,072. (*See*, in particular, Figure 1 of U.S. Serial No. 379,072).

The cloned monkey variable genes are then inserted into an expression vector which contains human heavy and light chain constant region genes. Preferably, this is effected using a proprietary expression vector of IDEC, Inc., referred to as NEOSPLA. This vector is shown in Figure 2 and contains the cytomegalovirus promoter/enhancer, the mouse beta globin major promoter, the SV40 origin of replication, the bovine growth

hormone polyadenylation sequence, neomycin phosphotransferase exon 1 and exon 2, human immunoglobulin kappa or lambda constant region, the dihydrofolate reductase gene, the human immunoglobulin gamma 1 or gamma 4 PE constant region and leader sequence. This vector has been found to result in very high level expression of primatized antibodies upon incorporation of monkey variable region genes, transfection in CHO cells, followed by selection in G418 containing medium and methotrexate amplification.

For example, this expression system has been previously disclosed to result in primatized antibodies having high avidity (Kd $\leq 10^{-10}$ M) against CD4 and other human cell surface receptors. Moreover, the antibodies have been found to exhibit the same affinity, specificity and functional activity as the original monkey antibody. This vector system is substantially disclosed in commonly assigned U.S. Serial No. 379,072, incorporated by reference herein as well as U.S. Serial No. 08/149,099, filed on November 3, 1993, also incorporated by reference in its entirety herein. This system provides for high expression levels, i.e., > 30 pg/cell/day.

As discussed *infra*, the subject inventors have selected four lead candidate monkey monoclonal antibodies which specifically bind the B7.1 antigen, and which may also bind the B7.2 antigen. These monkey monoclonal antibodies are referred to herein as 7B6, 16C10, 7C10 and 20C9.

As discussed in greater detail *infra*, these antibodies were evaluated for their ability to block B cell/T cell interactions as measured by IL-2 production and tritiated thymidine uptake in a mixed lymphocyte reaction for T cell binding experiments for T cell

binding, human body coat peripheral blood lymphocytes were cultured for 3-6 days in the presence of PHA stimulator. B7 binding was radioassayed using ^{125}I-radiolabeled soluble B7.1. The observed results indicate that all of these antibodies bind B7.1 antigen with high affinity and effectively block B cell/T cell interactions as evidenced by reduced IL-2 production and reduced proliferation of mixed lymphocyte cultures.

The properties of these particular monkey monoclonal antibodies are summarized below:

1. To demonstrate the monkey antibodies' ability to block the physical interaction between CTLA4-Ig, varying concentrations of the monkey anti-B7.1 antibodies and unlabeled CTLA4-IG were incubated with radiolabeled CTLA4-Ig^{I125}. The results of the inhibition assay showed that the IC50 (the concentration of inhibitor which results in 50% inhibition) for the monkey antibodies are:

   a: 7C10: 0.39 μg/Ml
   b: 16C10: 1.60 μg/Ml
   c: 20C9: 3.90 μg/Ml
   d: 7B6: 39.0 μg/Ml

2. Scatchard analysis showed that the apparent affinity constants (Kd) for the monkey antibodies binding to B7-Ig coated plates were approximated to be:

   a: 7C10: 6.2×10^{-9}M
   b: 16C10: 8.1×10^{-9}M
   c: 7B6: 10.7×10^{-9}M
   d: 20C9: 16.8×10^{-9}M

3. The antibodies were tested *in vitro* in a mixed lymphocyte reaction assay (MLR). The MLR

showed that all 4 anti-B7.1 antibodies inhibit IL-2 production to different extents as shown by the following Ibgo values:

a: 7B6: 5.0 μg/M
b: 16C10: <0.1 μg/M
c: 20C9: 2.0 μg/M
d: 7C10: 5.0 μg/M

4. The monkey anti-B7.1 antibodies were tested for their ability to bind B7 on human peripheral blood lymphocytes (PBL). FACS analysis showed that all 4 monkey antibodies tested positive.

5. Monkey antibodies 16C10, 7B6, 7C10 and 20C9 were tested for C1q binding by FACS analysis. Results showed 7C10 monkey Ig had strong human C1q binding after incubating with B7.1 CHO-transfected cells. 16C10 was positive, while 20C9 and 7B6 monkey antibodies were negative.

6. To select an animal model for path-tox studies, the monkey antibodies were tested with animal blood from different species. It was determined that the monkey anti-B7.1 antibodies cross-reacted with human, chimpanzee, and possibly baboon.

Based on these properties, it would appear that three monkey monoclonal antibodies possess the most advantageous properties, 16C10, 7C10 and 20C9, with 16C10 and 7C10 being somewhat better than 20C9.

Using the techniques described *supra*, and in commonly assigned U.S. Serial No. 08/379,072, the present inventors have cloned the variable domains of 7C10, 7B6 and 16C10, and provide the amino acid and nucleic acid sequences of primatized forms of the 7C10 light chain, 7C10 heavy chain, 7B6 light chain, 7B6 heavy chain, 16C10 light chain and 16C10 heavy chain.

These amino acid and nucleic acid sequences may be found in Figures 8a and 8b, 9a and 9b, and 10a and 10b. The DNA and amino acid sequence for the human gamma 1 constant domain may be found in U.S. Serial No. 08/379,072.

As discussed *supra*, these primatized antibodies are preferably expressed using the NEOSPLA expression vector shown in Figure 2 which is substantially described in commonly assigned 08/379,072 and 08/149,099, both of which applications are incorporated by reference herein.

As previously noted, the subject primatized antibodies will preferably contain either the human immunoglobulin gamma 1 or gamma 4 constant region, with gamma 4 preferably mutated at two positions to create gamma 4 PE. The gamma 4 PE mutant contains two mutations, a glutamic acid in the CH2 region introduced to eliminate residual FCR binding, and a proline substitution in the hinge region, intended to enhance the stability of the heavy chain disulfide bond interaction. (*See*, Alegre et al, J. Immunol., 148, 3461-3468, (1992); and Angel et al, Mol. Immunol., 30, 105-158, (1993), both of which are incorporated by reference herein).

Whether the subject primatized antibodies contain the gamma 1, gamma 4 or gamma 4 PE constant region largely depends on the particular disease target. Preferably, depleting and non-depleting primatized IgG1 and IgG4 antibodies are created and tested against specific disease targets.

Given the described binding and functional properties of the subject monkey monoclonal antibodies, these anti-B7.1 monoclonal antibodies and primatized forms thereof should be well suited as therapeutic agents for blocking the B7:CD28 interaction thereby

porviding for immunosuppression. In particular, given their high affinity to B7.1 antigen and ability to block B cell/T cell interactions as measured by IL-2 production and tritiated thymidine uptake in mixed lymphocyte culture as well as their ability to effectively inhibit antigen driven responses in donor spleen cell cultures as shown by reduced antigen specific IgG responses, IL-2 production and cell proliferation, these monkey monoclonal antibodies and primatized forms thereof should function as effective immunosuppressants which modulate the B7:CD28 pathway. This is significant for the treatment of many diseases wherein immunosuppression is therapeutically desirable, e.g., autoimmune diseases, to inhibit undesirable antigen specific IgG responses, and also for prevention of organ rejection and graft-versus-host disease. Essentially, the subject antibodies will be useful in treating any disease wherein suppression of the B7:CD28 pathway is therapeutically desirable.

Key therapeutic indications for the subject anti-B7.1 antibodies include, by way of example, autoimmune diseases such as idiopathic thrombocytopenia purpura (ITP), systemic lupus erythematosus (SLE), type 1 diabetes mellitus, multiple sclerosis, aplastic anemia, psoriasis and rheumatoid arthritis.

Another significant therapeutic indication of the subject anti-B7.1 antibodies is for prevention of graft-versus-host-disease (GVHD) during organ transplant and bone marrow transplant (BMT). The subject antibodies may be used to induce host tolerance to donor-specific alloantigens and thereby facilitate engraftment and reduce the incidence of graft rejection. It has been shown in a murine model of allogeneic cardiac transplantation that intravenous administration of

CTLA4-Ig can result in immunosuppression or even induction of tolerance to alloantigen. (Lin et al, J. Exp. Med. 178:1801, 1993; Torka et al, Proc. Natl. Acad. Sci., USA, 89:11102, 1992). It is expected that the subject primatized anti-B7.1 antibodies will exhibit similar or greater activity.

Antibodies produced in the manner described above, or by equivalent techniques, can be purified by a combination of affinity and size exclusion chromatography for characterization in functional biological assays. These assays include determination of specificity and binding affinity as well as effector function associated with the expressed isotype, e.g., ADCC, or complement fixation. Such antibodies may be used as passive or active therapeutic agents against a number of human diseases, including B cell lymphoma, infectious diseases including AIDS, autoimmune and inflammatory diseases, and transplantation. The antibodies can be used either in their native form, or as part of an antibody/chelate, antibody/drug or antibody/toxin complex. Additionally, whole antibodies or antibody fragments (Fab_2, Fab, Fv) may be used as imaging reagents or as potential vaccines or immunogens in active immunotherapy for the generation of anti-idiotypic responses.

The amount of antibody useful to produce a therapeutic effect can be determined by standard techniques well known to those of ordinary skill in the art. The antibodies will generally be provided by standard technique within a pharmaceutically acceptable buffer, and may be administered by any desired route. Because of the efficacy of the presently claimed antibodies and their tolerance by humans it is possible to administer these antibodies repetitively in order to

combat various diseases or disease states within a human.

The anti-B7.1 antibodies (or fragments thereof) of this invention are useful for inducing immunosuppression, i.e., inducing a suppression of a human's or animal's immune system. This invention therefore relates to a method of prophylactically or therapeutically inducing immunosuppression in a human or other animal in need thereof by administering an effective, non-toxic amount of such an antibody of this invention to such human or other animal.

The ability of the compounds of this invention to induce immunosuppression has been demonstrated in standard tests used for this purpose, for example, a mixed lymphocyte reaction test or a test measuring inhibition of T-cell proliferation measured by thymidine uptake.

The fact that the antibodies of this invention have utility in inducing immunosuppression indicates that they should be useful in the treatment or prevention of resistance to or rejection of transplanted organs or tissues (e.g., kidney, heart, lung, bone marrow, skin, cornea, etc.); the treatment or prevention of autoimmune, inflammatory, proliferative and hyperproliferative diseases, and of cutaneous manifestations of immunologically medicated diseases (e.g., rheumatoid arthritis, lupus erythematosus, systemic lupus erythematosus, Hashimotos thyroiditis, multiple sclerosis, myasthenia gravis, type 1 diabetes, uveitis, nephrotic syndrome, psoriasis, atopical dermatitis, contact dermatitis and further eczematous dermatitides, seborrheic dermatitis, Lichen planus, Pemplugus, bullous pemphigus, Epidermolysis bullosa, urticaria, angioedemas, vasculitides, erythema,

cutaneous eosinophilias, Alopecia areata, etc.); the treatment of reversible obstructive airways disease, intestinal inflammations and allergies (e.g., Coeliac disease, proctitis, eosinophilia gastroenteritis, mastocytosis, Crohn's disease and ulcerative colitis) and food-related allergies (e.g., migraine, rhinitis and eczema).

One skilled in the art would be able, by routine experimentation, to determine what an effective, non-toxic amount of antibody would be for the purpose of inducing immunosuppression. Generally, however, an effective dosage will be in the range of about 0.05 to 100 milligrams per kilogram body weight per day.

The antibodies (or fragments thereof) of this invention should also be useful for treating tumors in a mammal. More specifically, they should be useful for reducing tumor size, inhibiting tumor growth and/or prolonging the survival time of tumor-bearing animals. Accordingly, this invention also relates to a method of treating tumors in a human or other animal by administering to such human or animal an effective, non-toxic amount of an antibody. One skilled in the art would be able, by routine experimentation, to determine what an effective, non-toxic amount of anti-B7 antibody would be for the purpose of treating carcinogenic tumors. Generally, however, an effective dosage is expected to be in the range of about 0.05 to 100 milligrams per kilogram body weight per day.

The antibodies of the invention may be administered to a human or other animal in accordance with the aforementioned methods of treatment in an amount sufficient to produce such effect to a therapeutic or prophylactic degree. Such antibodies of the invention can be administered to such human or other animal in a

conventional dosage form prepared by combining the antibody of the invention with a conventional pharmaceutically acceptable carrier or diluent according to known techniques. It will be recognized by one of skill in the art that the form and character of the pharmaceutically acceptable carrier or diluent is dictated by the amount of active ingredient with which it is to be combined, the route of administration and other well-known variables.

The route of administration of the antibody (or fragment thereof) of the invention may be oral, parenteral, by inhalation or topical. The term parenteral as used herein includes intravenous, intraperitoneal, intramuscular, subcutaneous, rectal or vaginal administration. The subcutaneous and intramuscular forms of parenteral administration are generally preferred.

The daily parenteral and oral dosage regimens for employing compounds of the invention to prophylactically or therapeutically induce immunosuppression, or to therapeutically treat carcinogenic tumors will generally be in the range of about 0.05 to 100, but preferably about 0.5 to 10, milligrams per kilogram body weight per day.

The antibodies of the invention may also be administered by inhalation. By "inhalation" is meant intranasal and oral inhalation administration. Appropriate dosage forms for such administration, such as an aerosol formulation or a metered dose inhaler, may be prepared by conventional techniques. The preferred dosage amount of a compound of the invention to be employed is generally within the range of about 10 to 100 milligrams.

The antibodies of the invention may also be administered topically. By topical administration is meant non-systemic administration and includes the application of an antibody (or fragment thereof) compound of the invention externally to the epidermis, to the buccal cavity and instillation of such an antibody into the ear, eye and nose, and where it does not significantly enter the blood stream. By systemic administration is meant oral, intravenous, intraperitoneal and intramuscular administration. The amount of an antibody required for therapeutic or prophylactic effect will, of course, vary with the antibody chosen, the nature and severity of the condition being treated and the animal undergoing treatment, and is ultimately at the discretion of the physician. A suitable topical dose of an antibody of the invention will generally be within the range of about 1 to 100 milligrams per kilogram body weight daily.

Formulations

While it is possible for an antibody or fragment thereof to be administered alone, it is preferable to present it as a pharmaceutical formulation. The active ingredient may comprise, for topical administration, from 0.001% to 10% w/w, e.g., from 1% to 2% by weight of the formulation, although it may comprise as much as 10% w/w but preferably not in excess of 5% w/w and more preferably from 0.1% to 1% w/w of the formulation.

The topical formulations of the present invention, comprise an active ingredient together with one or more acceptable carrier(s) therefor and optionally any other therapeutic ingredients(s). The carrier(s) must be "acceptable" in the sense of being compatible with the

other ingredients of the formulation and not deleterious to the recipient thereof.

Formulations suitable for topical administration include liquid or semi-liquid preparations suitable for penetration through the skin to the site of where treatment is required, such as liniments, lotions, creams, ointments or pastes, and drops suitable for administration to the eye, ear or nose.

Drops according to the present invention may comprise sterile aqueous or oily solutions or suspensions and may be prepared by dissolving the active ingredient in a suitable aqueous solution of a bactericidal and/or fungicidal agent and/or any other suitable preservative, and preferably including a surface active agent. The resulting solution may then be clarified by filtration, transferred to a suitable container which is then sealed and sterilized by autoclaving or maintaining at 90°-100°C for half an hour. Alternatively, the solution may be sterilized by filtration and transferred to the container by an aseptic technique. Examples of bactericidal and fungicidal agents suitable for inclusion in the drops are phenylmercuric nitrate or acetate (0.002%), benzalkonium chloride (0.01%) and chlorhexidine acetate (0.01%). Suitable solvents for the preparation of an oily solution include glycerol, diluted alcohol and propylene glycol.

Lotions according to the present invention include those suitable for application to the skin or eye. An eye lotion may comprise a sterile aqueous solution optionally containing a bactericide and may be prepared by methods similar to those for the preparation of drops. Lotions or liniments for application to the skin may also include an agent to hasten drying and to cool

the skin, such as an alcohol or acetone, and/or a moisturizer such as glycerol or an oil such as castor oil or arachis oil.

Creams, ointments or pastes according to the present invention are semi-solid formulations of the active ingredient for external application. They may be made by mixing the active ingredient in finely-divided or powdered form, alone or in solution or suspension in an aqueous or non-aqueous fluid, with the aid of suitable machinery, with a greasy or non-greasy basis. The basis may comprise hydrocarbons such as hard, soft or liquid paraffin, glycerol, beeswax, a metallic soap; a mucilage; an oil of natural origin such as almond, corn, arachis, castor or olive oil; wool fat or its derivatives, or a fatty acid such as stearic or oleic acid together with an alcohol such as propylene glycol or macrogols. The formulation may incorporate any suitable surface active agent such as an anionic, cationic or non-ionic surface active such as sorbitan esters or polyoxyethylene derivatives thereof. Suspending agents such as natural gums, cellulose derivatives or inorganic materials such as silicaceous silicas, and other ingredients such as lanolin, may also be included.

The subject anti-B7.1 antibodies or fragments thereof may also be administered in combination with other moieties which modulate the B7:CD28 pathway. Such moieties include, by way of example, cytokines such as IL-7 and IL-10, CTLA4-Ig, soluble CTLA-4 and anti-CD28 antibodies and fragments thereof.

It will be recognized by one of skill in the art that the optimal quantity and spacing of individual dosages of an antibody or fragment thereof of the invention will be determined by the nature and extent of

the condition being treated, the form, route and site of administration, and the particular animal being treated, and that such optimums can be determined by conventional techniques. It will also be appreciated by one of skill in the art that the optimal course of treatment, i.e., the number of doses of an antibody or fragment thereof of the invention given per day for a defined number of days, can be ascertained by those skilled in the art using conventional course of treatment determination tests.

Without further elaboration, it is believed that one skilled in the art can, using the preceding description, utilize the present invention to its fullest extent. The following formulations are, therefore, to be construed as merely illustrative embodiments and not a limitation of the scope of the present invention in any way.

Capsule Composition

A pharmaceutical composition of this invention in the form of a capsule is prepared by filling a standard two-piece hard gelatin capsule with 50 mg. of an antibody or fragment thereof of the invention, in powdered form, 100 mg. of lactose, 32 mg. of talc and 8 mg. of magnesium stearate.

Injectable Parenteral Composition

A pharmaceutical composition of this invention in a form suitable for administration by injection is prepared by stirring 1.5% by weight of an antibody or fragment thereof of the invention in 10% by volume propylene glycol and water. The solution is sterilized by filtration.

Ointment Composition

Antibody or fragment thereof of the invention 1.0 g.

White soft paraffin to 100.0 g.

The antibody or fragment thereof of the invention is dispersed in a small volume of the vehicle to produce a smooth, homogeneous product. Collapsible metal tubes are then filled with the dispersion.

Topical Cream Composition

Antibody or fragment thereof of the invention 1.0 g.

Polawax GP 200 20.0 g.

Lanolin Anhydrous 2.0 g.

White Beeswax 2.5 g.

Methyl hydroxybenzoate 0.1 g.

Distilled Water to 100.0 g.

The polawax, beeswax and lanolin are heated together at 60°C. A solution of methyl hydroxybenzoate is added and homogenization is achieved using high speed stirring. The temperature is then allowed to fall to 50°C. The antibody or fragment thereof of the invention is then added and dispersed throughout, and the composition is allowed to cool with slow speed stirring.

Topical Lotion Composition

Antibody or fragment thereof of the invention 1.0 g.

Sorbitan Monolaurate 0.6 g.

Polysorbate 20 0.6 g.

Cetostearyl Alcohol 1.2 g.

Glycerin 6.0 g.

Methyl Hydroxybenzoate 0.2 g.

Purified Water B.P. to 100-00 ml. (B.P. = British Pharmacopeia)

The methyl hydroxybenzoate and glycerin are dissolved in 70 ml. of the water at 75°C. The sorbitan monolaurate, polysorbate 20 and cetostearyl alcohol are melted together at 75°C and added to the aqueous solution. The resulting emulsion is homogenized, allowed to cool with continuous stirring and the antibody or fragment thereof of the invention is added as a suspension in the remaining water. The whole suspension is stirred until homogenized.

Eye Drop Composition

Antibody or fragment thereof of the invention 0.5 g.

Methyl Hydroxybenzoate 0.01 g.

Propyl Hydroxybenzoate 0.04 g.

Purified Water B.P. to 100-00 ml.

The methyl and propyl hydroxybenzoates are dissolved in 70 ml. purified water at 75°C and the resulting solution is allowed to cool. The antibody or fragment thereof of the invention is then added, and the solution is sterilized by filtration through a membrane filter (0.022 μm pore size), and packed aseptically into suitable sterile containers.

Composition for Administration by Inhalation

For an aerosol container with a capacity of 15-20 ml: mix 10 mg. of an antibody or fragment thereof of the invention with 0.2-0.5% of a lubricating agent, such as polysorbate 85 or oleic acid, and disperse such mixture in a propellant, such as freon, preferably in a combination of (1,2 dichlorotetrafluoroethane) and difluorochloro-methane and put into an appropriate

aerosol container adapted for either intranasal or oral inhalation administration.

Composition for Administration by Inhalation

For an aerosol container with a capacity of 15-20 ml: dissolve 10 mg. of an antibody or fragment thereof of the invention in ethanol (6-8 ml.), add 0.1-0.2% of a lubricating agent, such as polysorbate 85 or oleic acid; and disperse such in a propellant, such as freon, preferably in combination of (1.2 dichlorotetrafluoroethane) and difluorochloromethane, and put into an appropriate aerosol container adapted for either intranasal or oral inhalation administration.

The antibodies and pharmaceutical compositions of the invention are particularly useful for parenteral administration, i.e., subcutaneously, intramuscularly or intravenously. The compositions for parenteral administration will commonly comprise a solution of an antibody or fragment thereof of the invention or a cocktail thereof dissolved in an acceptable carrier, preferably an aqueous carrier. A variety of aqueous carriers may be employed, e.g., water, buffered water, 0.4% saline, 0.3% glycine, and the like. These solutions are sterile and generally free of particulate matter. These solutions may be sterilized by conventional, well-known sterilization techniques. The compositions may contain pharmaceutically acceptable auxiliary substances as required to approximate physiological conditions such as Ph adjusting and buffering agents, etc. The concentration of the antibody or fragment thereof of the invention in such pharmaceutical formulation can vary widely, i.e., from less than about 0.5%, usually at or at least about 1% to as much as i5 or 20% by weight, and will be selected

primarily based on fluid volumes, viscosities, etc., according to the particular mode of administration selected.

Thus, a pharmaceutical composition of the invention for intramuscular injection could be prepared to contain 1 Ml sterile buffered water, and 50 mg. of an antibody or fragment thereof of the invention. Similarly, a pharmaceutical composition of the invention for intravenous infusion could be made up to contain 250 ml. of sterile Ringer's solution, and 150 mg. of an antibody or fragment thereof of the invention. Actual methods for preparing parenterally administrable compositions are well known or will be apparent to those skilled in the art, and are described in more detail in, for example, Remington's Pharmaceutical Science, 15th ed., Mack Publishing Company, Easton, Pennsylvania, hereby incorporated by reference herein.

The antibodies (or fragments thereof) of the invention can be lyophilized for storage and reconstituted in a suitable carrier prior to use. This technique has been shown to be effective with conventional immune globulins and art-known lyophilization and reconstitution techniques can be employed.

Depending on the intended result, the pharmaceutical composition of the invention can be administered for prophylactic and/or therapeutic treatments. In therapeutic application, compositions are administered to a patient already suffering from a disease, in an amount sufficient to cure or at least partially arrest the disease and its complications. In prophylactic applications, compositions containing the present antibodies or a cocktail thereof are

administered to a patient not already in a disease state to enhance the patient's resistance.

Single or multiple administrations of the pharmaceutical compositions can be carried out with dose levels and pattern being selected by the treating physician. In any event, the pharmaceutical composition of the invention should provide a quantity of the altered antibodies (or fragments thereof) of the invention sufficient to effectively treat the patient.

It should also be noted that the antibodies of this invention may be used for the design and synthesis of either peptide or non-peptide compounds (mimetics) which would be useful in the same therapy as the antibody. See, e.g., Saragovi et al., Science, 253, 792-795 (1991).

To further illustrate the invention, the following examples are provided. These examples are not intended, nor are they to be construed, as further limiting the invention.

Example 1

Recombinant immunoglobulin libraries displayed on the surface of filamentous phage were first described by McCafferty et al, Nature, 348:552-554, 1990 and Barbas et al, Proc. Natl. Acad. Sci., USA 88:7978-7982, 1991. Using this technology, high affinity antibodies have been isolated from immune human recombinant libraries (Barbas et al, Proc. Natl. Acad. Sci., USA 589:10164-10168, 1992). Although the phage display concept used is substantially similar to that described by Barbas, 1991, Id. the technique has been modified by the substitution of a unique vector for monkey libraries to reduce the possibility of recombination and improve stability. This vector, pMS, Figure 1 contains a single

lac promoter/operator for efficient transcription and translation of polycistronic heavy and light chain monkey DNA. This vector contains two different leader sequences, the omp A (Movva et al, J. Biol. Chem., 255: 27-29, (1980), for the light chain and the pel B (Lei, J. Bact., 4379-109:4383 (1987) for the heavy chain Fd. Both leader sequences are translated into hydrophobic signal peptides that direct the secretion of the heavy and light chain cloned products into the periplasmic space. In the oxidative environment of the periplasm, the two chains fold and disulfide bonds form to create stable Fab fragments. We derived the backbone of the vector from the phagemid bluescript. (Stratagene, La Jolla, CA). It contains the gene for the enzyme beta-lactamase that confers ampicillin (carbenicillin) resistance to bacteria that harbor pMS DNA. We also derived, from bluescript, the origin of replication of the multicopy plasmid ColE1 and the origin of replication of the filamentous bacteriophage f1. The origin of replication of phage f1 (the so-called intragenic region), signals the initiation of synthesis of single stranded pMS DNA, the initiation of capsid formation and the termination of RNA synthesis by viral enzymes. The replication and assembly of pMS DNA strands into phage particles requires viral proteins that must be provided by a helper phage. We have used helper phage VCSM13 which is particularly suited for this, since it also contains a gene coding for kanamycin resistance. Bacteria infected with VCSM13 and pMS can be selected by adding both kanamycin and carbenicillin to the growth medium. The bacteria will ultimately produce filamentous phage particles containing either pMS or VCSM13 genomes. Packaging of the helper phage is less efficient than that of pMS, resulting in a mixed

phage population that contains predominately recombinant pMS phages. The ends of the phage pick up minor coat proteins specific to each end. Of particular interest here is the gene III product which is present in three to five copies at one end of the phage. The gene III product is 406 amino acid residues and is required for phage infection of *E. coli* via the F pili. The first two domains of the heavy chain, the variable and the CH1 domain, are fused to the carboxy-terminal half of the gene III protein. This recombinant pili protein, directed by the pel B leader, is secreted to the peroplasm where it accumulates and forms disulfide bonds with the light chain before it is incorporated in the coat of the phage. Also, another vector contains a FLAG sequence engineered downstream of the gene III. The FLAG is an 8 amino acid peptide expressed at the carboxy terminal of the Fd protein. We are using commercially available monoclonal anti-FLAG M2 for both purification and detection of phage Fab by ELISA (Brizzard, Bio Techniques, 16(4):730-731, (1994)).

After constructing the vector pMS, we tested its ability to produce phage bound Fab using control antibody genes. We cloned an anti-tetanus toxoid antibody, (obtained from Dr. Carlos Barbas), into pMS and transformed XLI-blue. We co-infected our cells with VCSM13 and generated phage displaying the anti-tetanus toxoid antibody. We performed efficiency experiments where anti-tetanus toxoid phage were combined with phage beading an irrelevant antibody at 1:100,000. We performed three rounds of panning by applying 50 μl of the mixed phage to antigen (tetanus toxoid) coated polystyrene wells. Non-adherent phage were washed off and the adherent phage were eluted with acid. The eluted phage were used to infect a fresh aliquot of XL1-

Blue bacteria and helper phage was added. After overnight amplification, phage were prepared and again panned on antigen coated plates. After three rounds of panning, we were able to show that we had successfully enriched for the anti-tetanus toxoid phage. The success of this technology also depends on the ability to prepare soluble Fabs for characterization of the final panned product. This was achieved by excising gene III from the pMS DNA using the restriction enzyme Nhe I followed by re-ligation. After the gene III was excised, the Fab was no longer displayed on the phage surface but accumulated in the piroplasmic space. Lysates were prepared from bacteria expressing soluble Fab and tested for antigen specificity using an ELISA. High levels of soluble Fab were detected.

In order to adapt phage display technology for use with macaque libraries, we developed specific primers for PCR amplifying monkey immunoglobulin genes. These were based on macaque sequences we obtained while developing the PRIMATIZED™ antibody technology (*See*, 08/379,072, incorporated by reference herein) and databases containing human sequences. (Kabat et al, (1991), "Sequences of Proteins of Immunological Interest," U.S. Dept. of Health and Human Services, National Institute of Health).

We developed three sets of primers to cover amplification of the macaque repertoire. Our first set of primers was designed for amplification of the heavy chain VH and CH1 (Fd) domains. It consisted of a 3' CH1 domain primer and six 5' VH family specific primers that bind in the framework 1 region. Our second set of primers, for amplifying the whole lambda chain, covers the many lambda chain subgroups. It consists of a 3' primer and three 5' degenerate primers that bind in the

VL framework 1 region. Our third set of primers was designed for amplification of the kappa chain subgroups. It consists of one 3' primer and five VK framework 1 primers. Using each of these sets, PCR parameters were optimized to obtain strong enough signals from each primer pair so that ample material was available for cloning of the library. We recently created macaque combinatorial libraries in our pMS vector using these optimized PCR conditions. Bone marrow biopsies were taken from CD4 immune monkeys as the source of immunoglobulin RNA. The libraries contained approximately 10^6 members and are currently being panned for specific binders on antigen coated wells.

Example 2

Development of B7/CTLA-4 Reagents

We have generated a number of reagents for the purpose of immunizing monkeys, developing binding and functional assays *in vitro*, screening heterohybridomas and panning phage libraries. Table 1 lists each reagent and its intended purpose. In the case of B7.1, RNA was extracted from SB cells and converted to cDNA using reverse transcriptase. The first strand cDNA was PCR amplified using B7.1 specific primers and cloned into IDEC's NEOSPLA mammalian expression vectors. CHO cells were transfected with B7.1 NEOSPLA DNA and clones expressing membrane associated B7.1 were identified. The B7.1 fusion protein was generated similarly, except that the PCR amplified B7.1 gene was cloned into a NEOSPLA cassette vector containing the human CH2 and CH3 immunoglobulin genes. CHO cells were transformed with the B7.1/Ig NEOSPLA DNA and stable clones secreting B7.1/Ig fusion protein were amplified. In general, the B7.2 and CTLA4 reagents were generated in the same

manner, except that for B7.2 the RNA was isolated from human spleen cells that had been stimulated 24 hours with anti-Ig and IL-4, and for the CTLA4 constructs the gene source was PHA activated human T cells.

Table 1

Reagent	Purpose	CHO Expression
Soluble B7.1	Immunization, immunoassays	Yes
B7.1 Transfectant	Screening, ELISA	Yes
B7.1/Ig Fusion Protein	Inhibition studies, panning	Yes
B7.2 Transfectant	Screening, ELISA	Yes
B7.2/Ig Fusion Protein	Inhibition studies, panning	To be completed
CTLA4 Transfectant	Inhibition studies	To be completed
CTLA4/Ig	Inhibition studies	To be completed

The availability of these reagents, together with monoclonal antibodies to B7.1 (L3074) (Becton Dickinson, 1994) and B7.2 (Fun-1 (Engel et al, Blood, 84, 1402-1407, (1994) and purified goat and rabbit antisera, specifically developed to detect monkey Fab fragments, facilitates identification of antibodies having the desired properties.

Example 3

Investigation of the Immune Response in Cynomolgus Monkeys to Soluble and Cell Associated Human B7.1

To evaluate the feasibility of producing monkey antibodies to human B7.1 antigen, we first purified recombinant SB7.1 from CHO cell media by affinity chromatography using a L307.4-sepharose affinity column. SB7.1 was then injected, with adjuvant, into five mature cynomolgus macaques. After a 3 to 4 month period of booster immunizations, sera from the monkeys immunized with SB7.1 or human SB cells were tested for antigen binding.

Serum samples from the five monkeys immunized with SB7.1. and three additional animals immunized with B7.1 positive human SB cells, were tested for antibody titers against membrane associated B7.1 expressed in transfected CHO cells. The results summarized in Figure 3 showed that four out of five monkeys immunized with affinity-purified SB7.1 produced antibody titers in excess of 1:5000. The three animals immunized with SB cells containing cell associated B7.1 expressed lower titers of antibodies ranging from 1:1400 to 1:2800.

Example 4

We purified antibodies from sera of all eight immunized monkeys using SB7.1-sepharose and then tested their ability to bind to 1) SB7.1 coated plates in ELISA; 2) antigen positive B cells and 3) B7.1 CHO transfectomas. In addition, they were evaluated for their ability to block B cell interactions as measured by IL-2 production and tritiated thymidine uptake in a mixed lymphocyte reaction (MLR). For T cell binding experiments, human buffy coat peripheral blood lymphocytes were cultured for 3-6 days in the presence of PHA stimulator. B7 binding was detected by radio assay using ^{125}I-radiolabeled soluble B7.1 (SB7.1).

Example 5

Direct binding of monkey antibodies to radiolabeled SB7. ^{125}I radiolabeled SB7.1 was tested for binding to anti-B7.1 antibodies at 4, 1 and 0.25 μg/ml in solution. The results shown in Table 2 suggest that most of the antibodies produced by monkeys immunized with SB7.1 were capable of binding the affinity-purified ^{125}I-SB7.1 in a concentration dependent manner. To evaluate the specificity of binding to labeled SB7.1, unlabelled

concentration dependent manner. To evaluate the specificity of binding to labeled SB7.1, unlabelled SB7.1 competition experiments were done with antibodies from two animals. Affinity-purified antibodies from monkeys 1133 and 1144 were coated onto microwell plates at 400 ng/well. Affinity-purified unlabeled SB7.1 (500 and 100 ng/well) was used as competitor. The results shown in Figure 4 demonstrated that SB7.1 preparations are effective in inhibiting the ^{125}I-SB7.1 from binding to the antibodies.

Table 2

Binding of SB7-I^{125} to Monkey Antibodies Affinity Purified on a SB7-Sepharose Affinity Column

Antibody (μg/ml)	Monkey Numbers							
	769	908	1133	1135	1137	1139	1144	1146
4	175	213	9,056	12,771	4,318	226	5,781	108
1	106	142	6,569	7,940	3,401	110	3,901	80
0.25	95	104	1,803	2,673	1,219	100	1,186	94

Data are mean values of duplicate assays and represent cpm SB7-I^{125} bound.

Example 6

Direct binding of radiolabeled affinity-purified monkey antibodies to B7^{+} cells and inhibition by SB7.1.

Affinity-purified radiolabeled monkey anti-B7.1 antibodies from monkey PRI135 were compared with radiolabeled L307.4 MAb for direct binding to B7 positive human SB cells. As a specificity control, unlabeled SB7.1 (0.002 - 20 μg/mi) was added to compete with both radiolabeled antibodies. We demonstrated that monkey antibodies can bind cell associated B7.1 and are inhibited with SB7.1, as shown in Figure 5. Inhibition as high as 90% was observed with SB7.1.

Example 7

Direct binding of radiolabeled B7-Ig fusion protein to activated T cells and Inhibition by affinity-purified monkey antibodies.

Human peripheral blood T lymphocytes were activated for 3-6 days and tested for direct binding of ^{125}I-B7.1-Ig. Because of Fc receptor upregulation on activated human T cells, it was necessary to pre-incubate the cells with heat-aggregated pre-immune immunoglobulin to block Fc binding sites prior to addition of B7.1-Ig to the cells. A background control using SP2/0 murine myeloma cells was included to allow correction of the background binding. Figure 6 shows that inhibition of ^{125}I-B7.1-Ig fusion protein binding to activated T cells was achieved with affinity-purified monkey antibodies at concentrations from 200 to 8 μg/ml. Unlabeled SB7.1 and L307.4 MAb used as controls were also effective in inhibiting B7.1-Ig fusion protein cell binding.

Example 8

Inhibition of IL-2 production in mixed lymphocyte reactions by monkey anti-B7 antibodies.

The blocking of CD28/B7 interaction leads to inhibition of IL-2 production by T lymphocytes. In the experiment shown in Figure 7, affinity-purified monkey antibodies from two monkeys immunized with SB7.1 (monkeys 1137 and 1135) and one immunized with B7 positive SB cells (monkey 1146) were evaluated for their abilities to inhibit human T cell activation in mixed lymphocyte reaction (MLR), as measured by inhibition of IL-2 production. The results of this experiment show that affinity-purified anti-B7.1 antibodies from monkeys 1146 and 1137 inhibited IL-2 production when added at concentrations of 50 μg/ml. Monkey 1135 antibodies

could not be evaluated at the two highest concentrations due to lack of material, yet gave significant inhibition at lower concentrations. The murine MAb L307.4 was inhibitory at concentrations of 10 μg/ml. Other monkey sera tested at these concentrations were negative (data not shown). These results demonstrate that at least three of the monkeys immunized with both soluble and membrane associated forms of the B7 antigen are producing B7-blocking antibodies with immunosuppressive potential.

Example 9

Investigation of Cross-reactivity in B7.1 Immunized Monkey Serum to B7.2 Antigen.

Antibodies raised against B7.1 are to be tested for cross-reactivity to B7.2. Preliminary results using B7.1 affinity-purified antibodies from B7.1 immune sera provided suggestive evidence of binding to B7.2 transfected CHO cells (not shown). These data should be confirmed by using soluble B7.2Ig reagents. We will first purify additional monkey antibodies from B7.1 immunized animals by affinity chromatography on B7.1Ig--sepharose. We will then produce and purify B7.2Ig from CHO cells in sufficient quantities to prepare a B7.2Ig-sepharose affinity column. We will select from the B7.1 specific antibody population those antibodies which cross-react with B7.2 by binding to the B7.2Ig-sepharose column. Any cross-reactive antibodies identified will be further characterized by direct binding to both B7.1 and B7.2 transfected CHO cells and inhibition of binding to B7.2 transfected cells by B7.1Ig.

Example 10

Generation of a Phage Display Library

Recombinant phage display libraries are generated from B7.1 and B7.2 immune monkeys. Lymph node and bone marrow biopsies are performed 7-12 days after immunization to harvest RNA rich B cells and plasma cells. RNA is isolated from the lymphocytes using the method described by Chomczynski Anal. Biochem., 162(1), 156-159, (1987). RNA is converted to cDNA using an oligo dT primer and reverse transcriptase. The first strand cDNA is divided into aliquots and PCR amplified using the sets of kappa, lambda, and heavy chain Fd region primers described earlier and either Pfu polymerase (Stratagene, San Diego) or Taq polymerase (Promega, Madison). The heavy chain PCR amplified products are pooled, cut with Xho VSpe I restriction enzymes and cloned into the vector pMS. Subsequently, the light chain PCR products are pooled, cut with Sac I/Xba I restriction enzymes, and cloned to create the recombinant library. XLI-Blue *E. coli* is transformed with the library DNA and super-infected with VCSM13 to produce the phage displaying antibodies. The library is panned four rounds on polystyrene wells coated with B7.1 or B7.2 antigen. Individual phage clones from each round of panning are analyzed. The pMS vector DNA is isolated and the gene III excised. Soluble Fab fragments are generated and tested in ELISA for binding to B7.1 and B7.2.

Example 11

Characterization of Phage Fab Fragments

The monkey phage Fab fragments are characterized for their specificity and the ability to block B7.1-Ig and B7.2-Ig binding to CTLA-4-Ig or CTLA-4 transfected

cells. Phage fragments are also characterized for cross-reactivity after first panning for 4 rounds on the B7 species used for immunization in order to select for high affinity fragments. Fab fragments identified from four rounds of panning either on B7.1 or B7.2 antigen coated surfaces are scaled up by infection and grown in 24 hour fermentation cultures of E coli. Fragments are purified by Kodak FLAG binding to a anti-FLAG affinity column. Purified phage Fabs are tested for affinity by an ELISA based direct binding modified Scatchard analysis (Katoh et al, J. Chem. BioEng., 76:451-454, (1993)) using Goat anti-monkey Fab antibodies or anti-FLAG MAb conjugated with horseradish peroxidase. The anti-monkey Fab reagents will be absorbed against human heavy chain constant region Ig to remove any cross-reactivity to B7-Ig. Kd values are calculated for each fragment after measurements of direct binding to B7.1-Ig or B7.2-Ig coated plates.

Example 12

Phage Fab Fragment Blocking of CTLA-4/B7 Binding

Fab fragments most effectively blocking the binding of B7-Ig at the lowest concentrations are selected as lead candidates. Selections are made by competing off ^{125}I-B7-Ig binding to CTLA-4-Ig or CTLA-4 transfected cells. Additional selection criteria include, blocking of mixed lymphocyte reaction (MLR), as measured by inhibiting 3H-thymidine uptake in responder cells (Azuma et al, J. Exp. Med., 177:845-850,; Azuma et al, Nature, 301:76-79, (1993)) and direct analysis of IL-2 production using IL-2 assay kits. The three or four candidates which are most effective in inhibiting of MLR and CTLA-4 binding assays are chosen for cloning into the above-described mammalian expression vector for

transfection into CHO cells and expression of chimeric monkey/human antibodies.

Example 13

Generation of Monkey Heterohybridomas

Monkey heterohybridomas secreting monoclonal antibodies are generated from existing immunized animals whose sera tested positive for B7.1 and/or B7.2. Lymph node biopsies are taken from animals positive to either, or both, antigens. The method of hybridoma production is similar to the established method used for the generation of monkey anti-CD4 antibodies (Newman, 1992(Id.)). Monkeys with high serum titers will have sections of inguinal lymph nodes removed under anesthesia. Lymphocytes are washed from the tissue and fused with KH6/B5 heteromyeloma cells (Carrol et al, J. Immunol. Meth., 89:61-72, (1986)) using polyethylene glycol (PEG). Hybridomas are selected on H.A.T. media and stabilized by repeated subcloning in 96 well plates.

Monkey monoclonal antibodies specific for B7.1 antigen are screened for cross-reactivity to B7.2. Monkey anti-B7 antibodies will be characterized for blocking of B7/CTLA-4 binding using the ^{125}I-B7-Ig binding assay. Inhibition of MLR by 3H-Thymidine uptake and direct measurement of IL-2 production is used to select three candidates. Two candidates will be brought forward in Phase II studies and expressed in CHO cells while repeating all functional studies. For the purposes of developing an animal model for *in vivo* pharmacology, anti-B7 antibodies will be tested on cells of several animal species. The establishment of an animal model will allow preclinical studies to be carried out for the selected clinical indication.

Example 14

As discussed *supra*, using the above heterohybridoma methods, 4 lead monkey anti-B7.1 antibodies have been identified: 16C10, 7B6, 7C10 and 20C9. These antibodies were characterized as follows:

To demonstrate the monkey antibodies' ability to block the physical interaction between CTLA4-Ig, varying concentrations of the monkey anti-B7.1 antibodies and unlabeled CTLA4-Ig were incubated with radiolabeled CTLA4-Ig^{I125}. The results of the inhibition assay showed that the IC50 (the concentration of inhibitor which results in 50% inhibition) for the monkey antibodies are:

a: 7C10: 0.39 μg/Ml
b: 16C10: 1.60 μg/Ml
c: 20C9: 3.90 μg/Ml
d: 7B6: 39.0 μg/Ml

Scatchard analysis showed that the apparent affinity constants (Kd) for the monkey antibodies binding to B7-Ig coated plates were approximated to be:

a: 7C10: 6.2×10^{-9}M
b: 16C10: 8.1×10^{-9}M
c: 7B6: 10.7×10^{-9}M
d: 20C9: 16.8×10^{-9}M

The antibodies were tested *in vitro* in a mixed lymphocyte reaction assay (MLR). The MLR showed that all 4 anti-B7.1 antibodies inhibit IL-2 production to different extents:

a: 7B6: 5.0 μg/Ml
b: 16C10: 0.1 μg/Ml
c: 20C9: 2.0 μg/Ml
d: 7C10: 5.0 μg/Ml

The monkey anti-B7.1 antibodies were tested for their ability to bind B7 on human peripheral blood

lymphocytes (PBL). FACS analysis showed that all 4 monkey antibodies tested positive.

Monkey antibodies 16C10, 7B6, 7C10 and 20C9 were tested for C1q binding by FACS analysis. Results showed 7C10 monkey Ig had strong human C1q binding after incubating with B7.1 CHO-transfected cells. 16C10 was negative, as were the 20C9 and 7B6 monkey antibodies.

Example 15

Using the primatized antibody methodology incorporated by reference to commonly assigned U.S. Serial No. 08/379,072, and using the NEOSPLA vector system shown in Figure 2, the heavy and light variable domains of 7C10, 7B6 and 16C10 were cloned and primatized forms thereof have been synthesized in CHO cells using the NEOSPLA vector system. The amino acid and nucleic acid sequences for the primatized 7C10 light and heavy chain, 7B6 light and heavy chain, and 16C10 light and heavy chain are respectively shown in Figures 8a, 8b, 9a, 9b, 10a and 10b.

It is expected that these primatized antibodies, given their probable low antigenicity and human effector function, will be well suited as therapeutics. In fact, it has recently been shown that primatized 16C10 exhibits human $C1_9$ binding, whereas 16C10 does not.

Those skilled in the art will recognize or be able to ascertain using no more than routine experimentation many equivalents to the specific embodiments of the invention described herein. Such equivalents are intended to be embraced by the following claims.

What Is Claimed Is:

1. A monkey monoclonal antibody or a primatized form thereof which specifically binds human B7.1 antigen and/or human B7.2 antigen.

2. The antibody of claim 1 which is selected from the group consisting of 16C10, 7C10, 20C9 and 7B6.

3. The antibody of claim 1 which is a depleting antibody.

4. The antibody of claim 1 which is a non-depleting antibody.

5. A primatized antibody which specifically binds to human B7.1 antigen which contains the variable heavy and light domains of an antibody selected from the group consisting of 16C10, 7C10, 20C9 and 7B6.

6. The primatized antibody of claim 5 wherein said antibody is derived from 7C10 and has the amino acid sequence set forth in Figures 8a and 8b.

7. The primatized antibody of claim 6 which is encoded by the nucleic acid sequence set forth in Figures 8a and 8b.

8. The primatized antibody of claim 5 wherein said antibody is derived from 7B6 and has the amino acid sequence set forth in Figures 9a and 9b.

9. The primatized antibody of claim 8 wherein said antibody is encoded by the nucleic acid sequence set forth in Figures 9a and 9b.

10. The primatized antibody of claim 5 wherein said antibody is derived from 16C10 and has the amino acid sequence set forth in Figures 4a and 4b.

11. The primatized antibody of claim 5 wherein said antibody is encoded by the nucleic acid sequence set forth in Figures 10a and 10b.

12. A transfectoma which expresses a primatized antibody which specifically binds to human B7.1 and/or human B7.2 antigen.

13. The transfectoma of claim 12 which is a CHO cell.

14. The transfectoma of claim 13 wherein said cell expresses a primatized antibody having the amino acid sequence set forth in any one of Figures 8a, 8b, 9a, 9b, 10a and 10b.

15. A pharmaceutical composition suitable for treatment of a disease treatable by inhibition of B7-CD28 binding which comprises an antibody according to any one of claims 1 to 11.

16. A method of treating a disease by inhibition of the B7:CD28 pathway which comprises administering a therapeutically effective amount of at least one antibody according to any one of claims 1 to 11.

17. The method of claim 16 wherein said antibody is 16C10, 7C10, 20C9, 7B6 or a primatized form thereof.

18. The method of claim 16 wherein said disease is an autoimmune disorder.

19. The method of claim 16 wherein said disease is selected from idiopathic thrombocytopenia purpura, systemic lupus erythematosus, type 1 diabetes mellitus, rheumatoid arthritis, psoriasis and multiple sclerosis.

20. The method of claim 16 wherein said disease is graft-versus-host disease.

ABSTRACT

The present invention relates to the identification of macaque antibodies to human B7.1 and B7.2 by screening of phage display libraries or monkey heterohybridomas obtained using B lymphocytes from B7.1 and/or B7.2 immunized monkeys. More specifically, the invention provides four monkey monoclonal antibodies 7B6, 16C10, 7C10 and 20C9 which inhibit the B7:CD28 pathway and thereby function as effective immunosuppressants. The invention further provides the complete DNA and amino acid sequences of the light and heavy chain of three primatized antibodies derived from those monkey monoclonal antibodies which bind B7.1 and possibly B7.2, primatized 7C10, primatized 7B6 and primatized 16C10. These primatized and monkey antibodies may be used as specific immunosuppressants, e.g., for the treatment of autoimmune diseases and to prevent organ transplant rejection.

FIG. 1

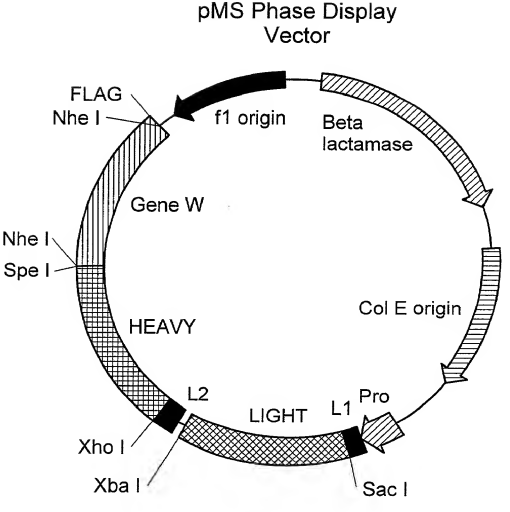
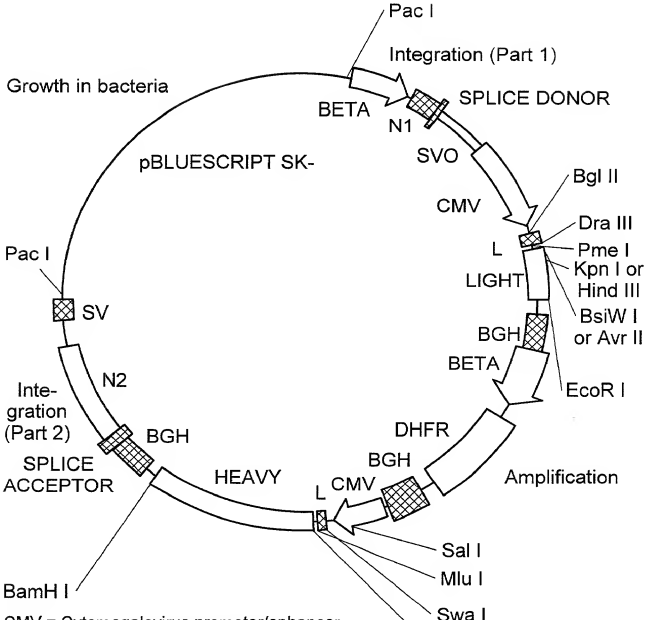

pMS Phase Display
Vector
FLAG
Nhe I
f1 origin
Beta
lactamase
Gene W
Nhe I
Spe I
HEAVY
Col E origin
L2
LIGHT
L1
Pro
Xho I
Xba I
Sac I

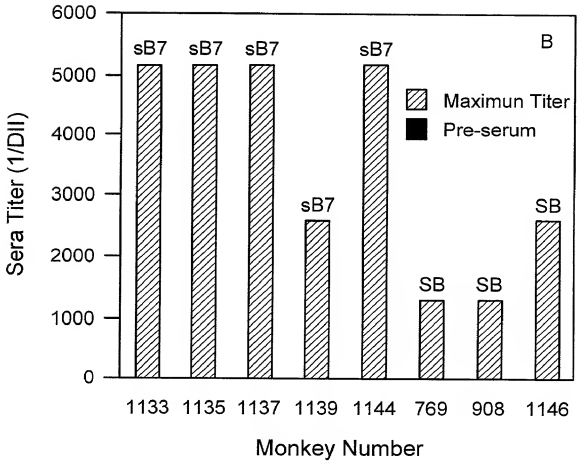
FIG. 2

NEOSPLA



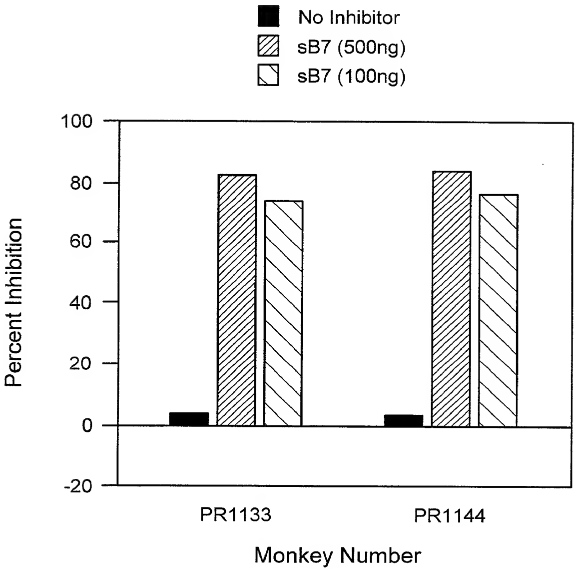
CMV = Cytomegalovirus promoter/enhancer
BETA = Mouse Beta globin major promoter
SVO = SV40 origin
BGH = Bovine growth hormone polyadenylation
SV = SV40 polyadenylation
N1 = Neomycin phosphotransferase exon 1
N2 = Neomycin phosphotransferase exon 2
LIGHT = Human immunonoglobulin kappa or lambda constant region
DHFR = Dihydrofolate Reductase
HEAVY = Human immunonoglobulin gamma 1 or gamma 4 PE constant region
L = Leader

FIG. 3



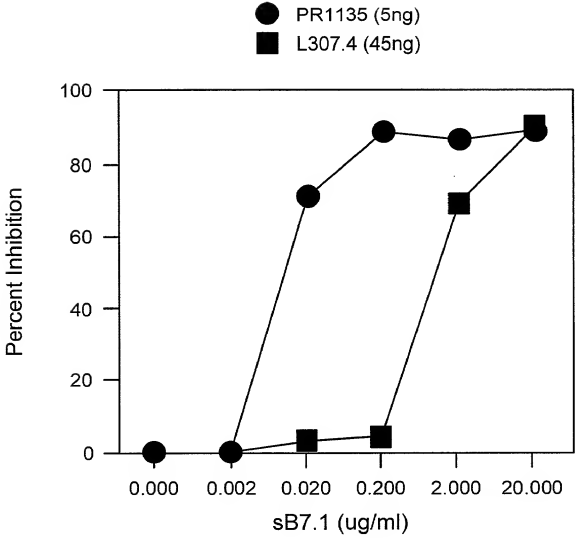
Monkey Serum Anti-B7.1 Titers Directed Against Cell Surface B7.1 on Transfected CHO Cells. Monkeys 1133-1139 were immunized with sB7.1. Monkeys 769-1146 were immunized with 50 million human B7 positive SB cells.

FIG. 4



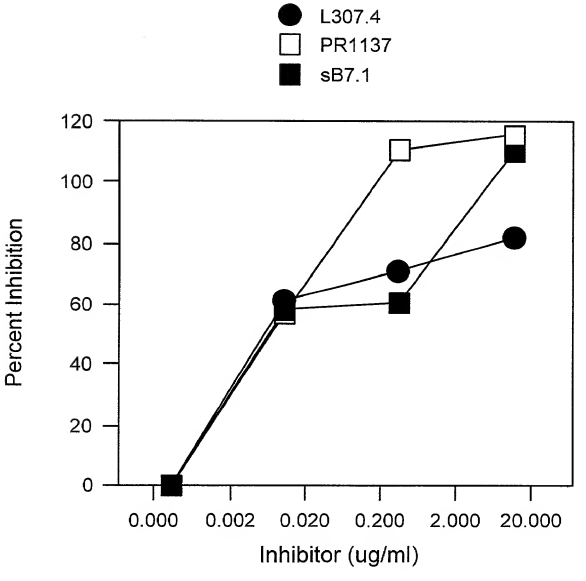
Inhibition of Radiolabeled sB7.1 Binding by sB7.1 Affinity-purified Monkey Antibodies in Presence of Unlabeled sB7 and MAb L307.4 Murine Anti-B7.1.

FIG. 5



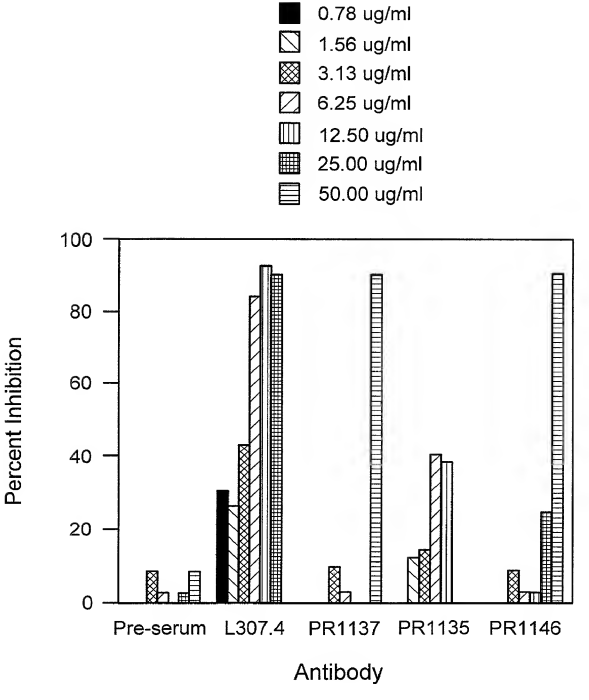
Inhibition of Binding of Radiolabeled Monkey 1135 and L307.4 Anti-B7.1 Antibodies to B7 Positive Human SB Cells by Competition With Affinity-Purified sB7.1.

FIG. 6



Inhibition of Radiolabeled B7-Ig Binding to Activated Human Peripheral Blood T Cells by Competing With Unlabeled sB7.1 Murine Anti-B7.1 (L307.4) and Monkey 1127 Affinity-purified Serum Antibodies.

FIG. 7



Inhibition of IL-2 Production in Mixed Lymphocyte Cultures by Anti-B7.1 Affinity-purified Monkey Serum Anibodies. Assays at some concentrations for certain monkeys were not done, due to limiting amounts of purified antibody.

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TRANSLATED FROM: 1 TO: 703 (ENTIRE REGION);
GENETIC CODE USED: UNIVERSAL; FRI, MAY 26, 1995 11:11 AM

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                  9               18              27
                  36

W   L   P   G   A   R   C   A   Y   E   L   T   Q   P   P
TGG CTC CCA GGT GCA CGA TGT GCC TAT GAA CTG ACT CAG CCA CCC
      45              54              63              72
                      81

S   V   S   V   S   P   G   Q   T   A   R   I   T   C   G
TCG GTG TCA GTG TCC CCA GGA CAG ACG GCC AGG ATC ACC TGT GGG
      90              99              108             117
                      126

G   D   N   S   R   N   E   Y   V   H   W   Y   Q   Q   K
GGA GAC AAC AGT AGA AAT GAA TAT GTC CAC TGG TAC CAG CAG AAG
      135             144             153             162
                      171

P   A   R   A   P   I   L   V   I   Y   D   D   S   D   R
CCA GCG CGG GCC CCT ATA CTG GTC ATC TAT GAT GAT AGT GAC CGG
      180             189             198             207
                      216

P   S   G   I   P   E   R   F   S   G   S   K   S   G   N
CCC TCA GGG ATC CCT GAG CGA TTC TCT GGC TCC AAA TCA GGG AAC
      225             234             243             252
                      261

T   A   T   L   T   I   N   G   V   E   A   G   D   E   A
ACC GCC ACC CTG ACC ATC AAC GGG GTC GAG GCC GGG GAT GAG GCT
      270             279             288             297
                      306

D   Y   Y   C   Q   V   W   D   R   A   S   D   H   P   V
GAC TAT TAC TGT CAG GTG TGG GAC AGG GCT AGT GAT CAT CCG GTC
      315             324             333             342
                      351

F   G   G   G   T   R   V   T   V   L   G   Q   P   K   A
TTC GGA GGA GGG ACC CGG GTG ACC GTC CTA GGT CAG CCC AAG GCT
      360             369             378             387
                      396

A   P   S   V   T   L   F   P   P   S   S   E   E   L   Q
GCC CCC TCG GTC ACT CTG TTC CCG CCC TCC TCT GAG GAG CTT CAA
      405             414             423             432
                      441

A   N   K   A   T   L   V   C   L   I   S   D   F   Y   P
GCC AAC AAG GCC ACA CTG GTG TGT CTC ATA AGT GAC TTC TAC CCG
      450             459             468             477
                      486
```

FIG. 8A - 1

```
G   A   V   T   V   A   W   K   A   D   S   S   P   V   K
GGA GCC GTG ACA GTG GCC TGG AAG GCA GAT AGC AGC CCC GTC AAG
    495         504         513         522         531

A   G   V   E   T   T   T   P   S   K   Q   S   N   N   K
GCG GGA GTG GAG ACC ACC ACA CCC TCC AAA CAA AGC AAC AAC AAG
    540         549         558         567         576

Y   A   A   S   S   Y   L   S   L   T   P   E   Q   W   K
TAC GCG GCC AGC AGC TAC CTG AGC CTG ACG CCT GAG CAG TGG AAG
    585         594         603         612         621

S   H   R   S   Y   S   C   Q   V   T   H   E   G   S   T
TCC CAC AGA AGC TAC AGC TGC CAG GTC ACG CAT GAA GGG AGC ACC
    630         639         648         657         666

V   E   K   T   V   A   P   T   E   C   S
GTG GAG AAG ACA GTG GCC CCT ACA GAA TGT TCA TGA
    675         684         693         702
```

FIG. 8A - 2

LENGTH OF 7C10 HEAVY/PRIMATIZED: 1431 bp; LISTED FROM: 1 TO: 1431
TRANSLATED FROM: 1 TO: 1429 (ENTIRE REGION);
GENETIC CODE USED: UNIVERSAL; FRI, MAY 26, 1995 11:11 AM

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              9          18          27          36

        P   R   W   V   L   S   Q   V   K   L   Q   Q   W   G   E
        CCC AGA TGG GTC CTG TCC CAG GTG AAG CTG CAG CAG TGG GGC GAA
          45          54          63          72          81

        G   L   L   Q   P   S   E   T   L   S   R   T   C   V   V
        GGA CTT CTG CAG CCT TCG GAG ACC CTG TCC CGC ACC TGC GTT GTC
          90          99          108         117         126

        S   G   G   S   I   S   G   Y   Y   Y   W   T   W   I   R
        TCT GGT GGC TCC ATC AGC GGT TAC TAC TAC TGG ACC TGG ATC CGC
          135         144         153         162         171

        Q   T   P   G   R   G   L   E   W   I   G   H   I   Y   G
        CAG ACC CCA GGG AGG GGA CTG GAG TGG ATT GGC CAT ATT TAT GGT
          180         189         198         207         216

        N   G   A   T   T   N   Y   N   P   S   L   K   S   R   V
        AAT GGT GCG ACC ACC AAC TAC AAT CCC TCC CTC AAG AGT CGA GTC
          225         234         243         252         261

        T   I   S   K   D   T   S   K   N   Q   F   F   L   N   L
        ACC ATT TCA AAA GAC ACG TCC AAG AAC CAG TTC TTC CTG AAC TTG
          270         279         288         297         306

        N   S   V   T   D   A   D   T   A   V   Y   Y   C   A   R
        AAT TCT GTG ACC GAC GCG GAC ACG GCC GTC TAT TAC TGT GCG AGA
          315         324         333         342         351

        G   P   R   P   D   C   T   T   I   C   Y   G   G   W   V
        GGC CCT CGC CCT GAT TGC ACA ACC ATT TGT TAT GGC GGC TGG GTC
          360         369         378         387         396

        D   V   W   G   P   G   D   L   V   T   V   S   S   A   S
        GAT GTC TGG GGC CCG GGA GAC CTG GTC ACC GTC TCC TCA GCT AGC
          405         414         423         432         441

        T   K   G   P   S   V   F   P   L   A   P   S   S   K   S
        ACC AAG GGC CCA TCG GTC TTC CCC CTG GCA CCC TCC TCC AAG AGC
          450         459         468         477         486
```

FIG. 8B - 1

T S G G T A A L G C L V K D Y
ACC TCT GGGGGC ACA GCG GCC CTG GGC TGC CTG GTC AAG GAC TAC
495 504 513 522 531

F P E P V T V S W N S G A L T
TTC CCC GAA CCG GTG ACG GTG TCG TGG AAC TCA GGC GCC CTG ACC
540 549 558 567 576

S G V H T F P A V L Q S S G L
AGC GGC GTG CAC ACC TTC CCG GCT GTC CTA CAG TCC TCA GGA CTC
585 594 603 612 621

Y S L S S V V T V P S S S L G
TAC TCC CTC AGC AGC GTG GTG ACC GTG CCC TCC AGC AGC TTG GGC
630 639 648 657 666

T Q T Y I C N V N H K P S N T
ACC CAG ACC TAC ATC TGC AAC GTG AAT CAC AAG CCC AGC AAC ACC
675 684 693 702 711

K V D K K A E P K S C D K T H
AAG GTG GAC AAG AAA GCA GAG CCC AAA TCT TGT GAC AAA ACT CAC
720 729 738 747 756

T C P P C P A P E L L G G P S
ACA TGC CCA CCG TGC CCA GCA CCT GAA CTC CTG GGG GGA CCG TCA
765 774 783 792 801

V F L F P P K P K D T L M I S
GTC TTC CTC TTC CCC CCA AAA CCC AAG GAC ACC CTC ATG ATC TCC
810 819 828 837 846

R T P E V T C V V V D V S H E
CGG ACC CCT GAG GTC ACA TGC GTG GTG GTG GAC GTG AGC CAC GAA
855 864 873 882 891

D P E V K F N W Y V D G V E V
GAC CCT GAG GTC AAG TTC AAC TGG TAC GTG GAC GGC GTG GAG GTG
900 909 918 927 936

H N A K T K P R E E Q Y N S T
CAT AAT GCC AAG ACA AAG CCG CGG GAG GAG CAG TAC AAC AGC ACG
945 954 963 972 981

Y R V V S V L T V L H Q D W L
TAC CGT GTG GTC AGC GTC CTC ACC GTC CTG CAC CAG GAC TGG CTG
990 999 1008 1017 1026

FIG. 8B - 2

N G K E Y K C K V S N K A L P
AAT GGC AAG GAG TAC AAG TGC AAG GTC TCC AAC AAA GCC CTC CCA
1035 1044 1053 1062 1071

A P I E K T I S K A K G Q P R
GCC CCC ATC GAG AAA ACC ATC TCC AAA GCC AAA GGG CAG CCC CGA
1080 1089 1098 1107 1116

E P Q V Y T L P P S R D E L T
GAA CCA CAG GTG TAC ACC CTG CCC CCA TCC CGG GAT GAG CTG ACC
1125 1134 1143 1152 1161

K N Q V S L T C L V K G F Y P
AAG AAC CAG GTC AGC CTG ACC TGC CTG GTC AAA GGC TTC TAT CCC
1170 1179 1188 1197 1206

S D I A V E W E S N G Q P E N
AGC GAC ATC GCC GTG GAG TGG GAG AGC AAT GGG CAG CCG GAG AAC
1215 1224 1233 1242 1251

N Y K T T P P V L D S D G S F
AAC TAC AAG ACC ACG CCT CCC GTG CTG GAC TCC GAC GGC TCC TTC
1260 1269 1278 1287 1296

F L Y S K L T V D K S R W Q Q
TTC CTC TAC AGC AAG CTC ACC GTG GAC AAG AGC AGG TGG CAG CAG
1305 1314 1323 1332 1341

G N V F S C S V M H E A L H N
GGG AAC GTC TTC TCA TGC TCC GTG ATG CAT GAG GCT CTG CAC AAC
1350 1359 1368 1377 1386

H Y T Q K S L S L S P G K .
CAC TAC ACG CAG AAG AGC CTC TCC CTG TCT CCG GGT AAA TGA
1395 1404 1413 1422 1431

FIG. 8B - 3

LENGTH OF 7B6 LIGHT/PRIMATIZED: 720 bp; LISTED FROM: 1 TO: 720;
TRANSLATED FROM: 1 TO: 718 (ENTIRE REGION);
GENETIC CODE USED: UNIVERSAL; FRI, MAY 26, 1995 11:10 AM

```
FRAME 1 M   S   L   P   A   Q   L   L   G   L   L   L   L
        ATG AGC CTC CCT GCT CAG CTC CTC GGGCTG CTA TTG CTC
                  9              18              27              36

C   V   P   G   S   S   G   E   V   V   M   T   Q   S   P
TGC GTC CCC GGGTCC AGT GGGGAA GTT GTG ATG ACT CAG TCT CCA
    45              54              63              72              81

L   S   L   P   I   T   P   G   E   P   A   S   I   S   C
CTG TCC CTT CCC ATC ACA CCT GGA GAG CCG GCC TCC ATC TCC TGT
    90              99              108             117             126

R   S   S   Q   S   L   K   H   S   N   G   D   T   F   L
AGG TCT AGT CAA AGC CTT AAA CAC AGT AAT GGA GAC ACC TTC CTG
    135             144             153             162             171

S   W   Y   Q   Q   K   P   G   Q   P   P   R   L   L   I
AGT TGG TAT CAG CAG AAG CCA GGC CAA CCT CCA AGG CTC CTG ATT
    180             189             198             207             216

Y   K   V   S   N   R   D   S   G   V   P   D   R   F   S
TAT AAG GTT TCT AAC CGG GAC TCT GGGGTC CCA GAC AGA TTC AGC
    225             234             243             252             261

G   S   G   A   G   T   D   F   T   L   K   I   S   A   V
GGC AGT GGG GCA GGGACA GAT TTC ACA CTG AAA ATC AGC GCA GTG
    270             279             288             297             306

E   A   E   D   V   G   V   Y   F   C   G   Q   G   T   R
GAG GCT GAA GAT GTT GGGGTT TAT TTC TGC GGGCAA GGT ACA AGG
    315             324             333             342             351

T   P   P   T   F   G   G   G   T   K   V   E   I   K   R
ACT CCT CCC ACT TTC GGC GGA GGGACC AAG GTG GAA ATC AAA CGT
    360             369             378             387             396

T   V   A   A   P   S   V   F   I   F   P   P   S   D   E
ACG GTG GCT GCA CCA TCT GTC TTC ATC TTC CCG CCA TCT GAT GAG
    405             414             423             432             441

Q   L   K   S   G   T   A   S   V   V   C   L   L   N   N
CAG TTG AAA TCT GGA ACT GCC TCT GTT GTG TGC CTG CTG AAT AAC
    450             459             468             477             486
```

FIG. 9A - 1

F Y P R E A K V Q W K V D N A
TTC TAT CCC AGA GAG GCC AAA GTA CAG TGG AAG GTG GAT AAC GCC
495 504 513 522 531

L Q S G N S Q E S V T E Q D S
CTC CAA TCG GGT AAC TCC CAG GAG AGT GTC ACA GAG CAG GAC AGC
540 549 558 567 576

K D S T Y S L S S T L T L S K
AAG GAC AGC ACC TAC AGC CTC AGC AGC ACC CTG ACG CTG AGC AAA
585 594 603 612 621

A D Y E K H K V Y A C E V T H
GCA GAC TAC GAG AAA CAC AAA GTC TAC GCC TGC GAA GTC ACC CAT
630 639 648 657 666

Q G L S S P V T K S F N R G E
CAG GGC CTG AGC TCG CCC GTC ACA AAG AGC TTC AAC AGG GGA GAG
675 684 693 702 711

C .
TGT TGA
720

FIG. 9A - 2

LENGTH OF 7B6 HEAVY/PRIMATIZED: 1437 bp; LISTED FROM: 1 TO: 1437
TRANSLATED FROM: 1 TO: 1435 (ENTIRE REGION);
GENETIC CODE USED: UNIVERSAL; FRI, MAY 26, 1995 11:09 AM

```
FRAME 1 M   G   W   S   L   I   L   L   F   L   V   A   V
        ATG GGT TGG AGC CTC ATC TTG CTC TTC CTT GTC GCT GTT
                 9          18          27          36

A   T   R   V   Q   C   E   V   Q   L   V   E   S   G   G
GCT ACG CGT GTC CAG TGT GAG GTG CAA CTG GTG GAG TCT GGGGGA
     45          54          63          72          81

G   L   V   Q   P   G   G   S   L   R   V   S   C   A   V
GGC TTG GTC CAG CCT GGC GGG TCC CTG AGA GTC TCC TGT GCA GTC
     90          99          108         117         126

S   G   F   T   F   S   D   H   Y   M   Y   W   F   R   Q
TCT GGA TTC ACC TTC AGT GAC CAC TAC ATG TAT TGG TTC CGC CAG
     135         144         153         162         171

A   P   G   K   G   P   E   W   V   G   F   I   R   N   K
GCT CCA GGGAAG GGGCCG GAA TGG GTA GGT TTC ATT AGA AAC AAA
     180         189         198         207         216

P   N   G   G   T   T   E   Y   A   A   S   V   K   D   R
CCG AAC GGT GGGACA ACA GAA TAC GCC GCG TCT GTG AAA GAC AGA
     225         234         243         252         261

F   T   I   S   R   D   D   S   K   S   I   A   Y   L   Q
TTC ACC ATC TCC AGA GAT GAT TCC AAA AGC ATC GCC TAT CTG CAA
     270         279         288         297         306

M   S   S   L   K   I   E   D   T   A   V   Y   Y   C   T
ATG AGC AGC CTG AAA ATC GAG GAC ACG GCC GTC TAT TAC TGT ACT
     315         324         333         342         351

T   S   Y   I   S   H   C   R   G   G   V   C   Y   G   G
ACA TCC TAC ATT TCA CAT TGT CGG GGT GGT GTC TGC TAT GGA GGT
     360         369         378         387         396

Y   F   E   F   W   G   Q   G   A   L   V   T   V   S   S
TAC TTC GAA TTC TGG GGC CAG GGC GCC CTG GTC ACC GTC TCC TCA
     405         414         423         432         441

A   S   T   K   G   P   S   V   F   P   L   A   P   S   S
GCT AGC ACC AAG GGC CCA TCG GTC TTC CCC CTG GCA CCC TCC TCC
     450         459         468         477         486
```


FIG. 9B - 1

K S T S G G T A A L G C L V K
AAG AGC ACC TCT GGG GGC ACA GCG GCC CTG GGC TGC CTG GTC AAG
495 504 513 522 531

D Y F P E P V T V S W N S G A
GAC TAC TTC CCC GAA CCG GTG ACG GTG TCG TGG AAC TCA GGC GCC
540 549 558 567 576

L T S G V H T F P A V L Q S S
CTG ACC AGC GGC GTG CAC ACC TTC CCG GCT GTC CTA CAG TCC TCA
585 594 603 612 621

G L Y S L S S V V T V P S S S
GGA CTC TAC TCC CTC AGC AGC GTG GTG ACC GTG CCC TCC AGC AGC
630 639 648 657 666

L G T Q T Y I C N V N H K P S
TTG GGC ACC CAG ACC TAC ATC TGC AAC GTG AAT CAC AAG CCC AGC
675 684 693 702 711

N T K V D K K A E P K S C D K
AAC ACC AAG GTG GAC AAG AAA GCA GAG CCC AAA TCT TGT GAC AAA
720 729 738 747 756

T H T C P P C P A P E L L G G
ACT CAC ACA TGC CCA CCG TGC CCA GCA CCT GAA CTC CTG GGG GGA
765 774 783 792 801

P S V F L F P P K P K D T L M
CCG TCA GTC TTC CTC TTC CCC CCA AAA CCC AAG GAC ACC CTC ATG
810 819 828 837 846

I S R T P E V T C V V V D V S
ATC TCC CGG ACC CCT GAG GTC ACA TGC GTG GTG GTG GAC GTG AGC
855 864 873 882 891

H E D P E V K F N W Y V D G V
CAC GAA GAC CCT GAG GTC AAG TTC AAC TGG TAC GTG GAC GGC GTG
900 909 918 927 936

E V H N A K T K P R E E Q Y N
GAG GTG CAT AAT GCC AAG ACA AAG CCG CGG GAG GAG CAG TAC AAC
945 954 963 972 981

S T Y R V V S V L T V L H Q D
AGC ACG TAC CGT GTG GTC AGC GTC CTC ACC GTC CTG CAC CAG GAC
990 999 1008 1017 1026

FIG. 9B - 2

W L N G K E Y K C K V S N K A
TGG CTG AAT GGC AAG GAG TAC AAG TGC AAG GTC TCC AAC AAA GCC
1035 1044 1053 1062 1071

L P A P I E K T I S K A K G Q
CTC CCA GCC CCC ATC GAG AAA ACC ATC TCC AAA GCC AAA GGG CAG
1080 1089 1098 1107 1116

P R E P Q V Y T L P P S R D E
CCC CGA GAA CCA CAG GTG TAC ACC CTG CCC CCA TCC CGG GAT GAG
1125 1134 1143 1152 1161

L T K N Q V S L T C L V K G F
CTG ACC AAG AAC CAG GTC AGC CTG ACC TGC CTG GTC AAA GGC TTC
1170 1179 1188 1197 1206

Y P S D I A V E W E S N G Q P
TAT CCC AGC GAC ATC GCC GTG GAG TGG GAG AGC AAT GGG CAG CCG
1215 1224 1233 1242 1251

E N N Y K T T P P V L D S D G
GAG AAC AAC TAC AAG ACC ACG CCT CCC GTG CTG GAC TCC GAC GGC
1260 1269 1278 1287 1296

S F F L Y S K L T V D K S R W
TCC TTC TTC CTC TAC AGC AAG CTC ACC GTG GAC AAG AGC AGG TGG
1305 1314 1323 1332 1341

Q Q G N V F S C S V M H E A L
CAG CAG GGG AAC GTC TTC TCA TGC TCC GTG ATG CAT GAG GCT CTG
1350 1359 1368 1377 1386

H N H Y T Q K S L S L S P G K
CAC AAC CAC TAC ACG CAG AAG AGC CTC TCC CTG TCT CCG GGT AAA
1395 1404 1413 1422 1431

TGA

FIG. 9B - 3

LENGTH OF 16C10 LAMBDA/PRIMATIZED: 711 bp; LISTED FROM: 1 TO: 711;
TRANSLATED FROM: 1 TO: 709 (ENTIRE REGION);
GENETIC CODE USED: UNIVERSAL; FRI, MAY 26, 1995 11:08 AM

```
FRAME 1 M   R   V   P   A   Q   L   L   G   L   L   L   L
        ATG AGG GTC CCC GCT CAG CTC CTG GGG CTC CTG CTG CTC
                9           18          27          36

        W   L   P   G   A   R   C   E   S   V   L   T   Q   P   P
        TGG CTC CCA GGT GCA CGA TGT GAG TCT GTC CTG ACA CAG CCG CCC
            45          54          63          72          81

        S   V   S   G   A   P   G   Q   K   V   T   I   S   C   T
        TCA GTG TCT GGG GCC CCA GGG CAG AAG GTC ACC ATC TCG TGC ACT
            90          99          108         117         126

        G   S   T   S   N   I   G   G   Y   D   L   H   W   Y   Q
        GGG AGC ACC TCC AAC ATT GGA GGT TAT GAT CTA CAT TGG TAC CAG
            135         144         153         162         171

        Q   L   P   G   T   A   P   K   L   L   I   Y   D   I   N
        CAG CTC CCA GGA ACG GCC CCC AAA CTC CTC ATC TAT GAC ATT AAC
            180         189         198         207         216

        K   R   P   S   G   I   S   D   R   F   S   G   S   K   S
        AAG CGA CCC TCA GGA ATT TCT GAC CGA TTC TCT GGC TCC AAG TCT
            225         234         243         252         261

        G   T   A   A   S   L   A   I   T   G   L   Q   T   E   D
        GGT ACC GCG GCC TCC CTG GCC ATC ACT GGG CTC CAG ACT GAG GAT
            270         279         288         297         306

        E   A   D   Y   Y   C   Q   S   Y   D   S   S   L   N   A
        GAG GCT GAT TAT TAC TGC CAG TCC TAT GAC AGC AGC CTG AAT GCT
            315         324         333         342         351

        Q   V   F   G   G   G   T   R   L   T   V   L   G   Q   P
        CAG GTA TTC GGA GGA GGG ACC CGG CTG ACC GTC CTA GGT CAG CCC
            360         369         378         387         396

        K   A   A   P   S   V   T   L   F   P   P   S   S   E   E
        AAG GCT GCC CCC TCG GTC ACT CTG TTC CCG CCC TCC TCT GAG GAG
            405         414         423         432         441

        L   Q   A   N   K   A   T   L   V   C   L   I   S   D   F
        CTT CAA GCC AAC AAG GCC ACA CTG GTG TGT CTC ATA AGT GAC TTC
            450         459         468         477         486
```

FIG. 10A - 1

```
Y   P   G   A   V   T   V   A   W   K   A   D   S   S   P
TAC CCG GGA GCC GTG ACA GTG GCC TGG AAG GCA GAT AGC AGC CCC
    495         504         513         522         531

V   K   A   G   V   E   T   T   T   P   S   K   Q   S   N
GTC AAG GCG GGA GTG GAG ACC ACC ACA CCC TCC AAA CAA AGC AAC
    540         549         558         567         576

N   K   Y   A   A   S   S   Y   L   S   L   T   P   E   Q
AAC AAG TAC GCG GCC AGC AGC TAC CTG AGC CTG ACG CCT GAG CAG
    585         594         603         612         621

W   K   S   H   R   S   Y   S   C   Q   V   T   H   E   G
TGG AAG TCC CAC AGA AGC TAC AGC TGC CAG GTC ACG CAT GAA GGG
    630         639         648         657         666

S   T   V   E   K   T   V   A   P   T   E   C   S   .
AGC ACC GTG GAG AAG ACA GTG GCC CCT ACA GAA TGT TCA TGA
    675         684         693         702         711
```

FIG. 10A - 2

LENGTH OF 16C10 HEAVY/PRIMATIZED: 1431 bp; LISTED FROM: 1 TO: 1431;
TRANSLATED FROM: 1 TO: 1429 (ENTIRE REGION);
GENETIC CODE USED: UNIVERSAL; FRI, MAY 26, 1995 11:08 AM

```
FRAME 1 M   K   H   L   W   F   F   L   L   L   V   A   A
        ATG AAA CAC CTG TGG TTC TTC CTC CTC CTG GTG GCA GCT
                  9              18              27              36

        P   R   W   V   L   S   Q   V   Q   L   Q   E   S   G   P
        CCC AGA TGG GTC CTG TCC CAG GTG CAG CTG CAG GAG TCG GGC CCA
              45              54              63              72              81

        G   L   V   K   P   S   E   T   L   S   L   T   C   A   V
        GGA CTG GTG AAG CCT TCG GAG ACC CTG TCC CTC ACC TGC GCT GTC
              90              99              108             117             126

        S   G   G   S   I   S   G   G   Y   G   W   G   W   I   R
        TCT GGT GGC TCC ATC AGC GGT GGT TAT GGC TGG GGC TGG ATC CGC
              135             144             153             162             171

        Q   P   P   G   K   G   L   E   W   I   G   S   F   Y   S
        CAG CCC CCA GGG AAG GGG CTG GAG TGG ATT GGG AGT TTC TAT AGT
              180             189             198             207             216

        S   S   G   N   T   Y   Y   N   P   S   L   K   S   Q   V
        AGT AGT GGG AAC ACC TAC TAC AAC CCC TCC CTC AAG AGT CAA GTC
              225             234             243             252             261

        T   I   S   T   D   T   S   K   N   Q   F   S   L   K   L
        ACC ATT TCA ACA GAC ACG TCC AAG AAC CAG TTC TCC CTG AAG CTG
              270             279             288             297             306

        N   S   M   T   A   A   D   T   A   V   Y   Y   C   V   R
        AAC TCT ATG ACC GCC GCG GAC ACG GCC GTG TAT TAC TGT GTG AGA
              315             324             333             342             351

        D   R   L   F   S   V   V   G   M   V   Y   N   N   W   F
        GAT CGT CTT TTT TCA GTT GTT GGA ATG GTT TAC AAC AAC TGG TTC
              360             369             378             387             396

        D   V   W   G   P   G   V   L   V   T   V   S   S   A   S
        GAT GTC TGG GGC CCG GGA GTC CTG GTC ACC GTC TCC TCA GCT AGC
              405             414             423             432             441

        T   K   G   P   S   V   F   P   L   A   P   S   S   K   S
        ACC AAG GGC CCA TCG GTC TTC CCC CTG GCA CCC TCC TCC AAG AGC
              450             459             468             477             486
```

FIG. 10B - 1

T S G G T A A L G C L V K D Y
ACC TCT GGG GGC ACA GCG GCC CTG GGC TGC CTG GTC AAG GAC TAC
495 504 513 522 531

F P E P V T V S W N S G A L T
TTC CCC GAA CCG GTG ACG GTG TCG TGG AAC TCA GGC GCC CTG ACC
540 549 558 567 576

S G V H T F P A V L Q S S G L
AGC GGC GTG CAC ACC TTC CCG GCT GTC CTA GAC TCC TCA GGA CTC
585 594 603 612 621

Y S L S S V V T V P S S S L G
TAC TCC CTC AGC AGC GTG GTG ACC GTG CCC TCC AGC AGC TTG GGC
630 639 648 657 666

T Q T Y I C N V N H K P S N T
ACC CAG ACC TAC ATC TGC AAC GTG AAT CAC ACA TGC CCA AAC ACC
675 684 693 702 711

K V D K K A E P K S C D K T H
AAG GTG GAC AAG AAA GCA GAG CCC AAA TCT TGT GAC AAA ACT CAC
720 729 738 747 756

T C P P C P A P E L L G G P S
ACA TGC CCA CCG TGC CCA GCA CCT GAA CTC CTG GGG GGA CCG TCA
765 774 783 792 801

V F L F P P K P K D T L M I S
GTC TTC CTC TTC CCC CCA AAA CCC AAG GAC ACC CTC ATG ATC TCC
810 819 828 837 846

R T P E V T C V V V D V S H E
CGG ACC CCT GAG GTC ACA TGC GTG GTG GTG GAC GTG AGC CAC GAA
855 864 873 882 891

D P E V K F N W Y V D G V E V
GAC CCT GAG GTC AAG TTC AAC TGG TAC GTG GAC GGC GTG GAG GTG
900 909 918 927 936

H N A K T K P R E E Q Y N S T
CAT AAT GCC AAG ACA AAG CCG CGG GAG GAG CAG TAC AAC AGC ACG
945 954 963 972 981

Y R V V S V L T V L H Q D W L
TAC CGT GTG GTC AGC GTC CTC ACC GTC CTG CAC CAG GAC TGG CTG
990 999 1008 1017 1026

FIG. 10B - 2

N G K E Y K C K V S N K A L P
AAT GGC AAG GAG TAC AAG TGC AAG GTC TCC AAC AAA GCC CTC CCA
1035 1044 1053 1062 1071

A P I E K T I S K A K G Q P R
GCC CCC ATC GAG AAA ACC ATC TCC AAA GCC AAA GCC AAA CCC CGA
1080 1089 1098 1107 1116

E P Q V Y T L P P S R D E L T
GAA CCA CAG GTG TAC ACC CTG CCC CCA TCC CGG GAT GAG CTG ACC
1125 1134 1143 1152 1161

K N Q V S L T C L V K G F Y P
AAG AAC CAG GTC AGC CTG ACC TGC CTG GTC AAA GGC TTC TAT CCC
1170 1179 1188 1197 1206

S D I A V E W E S N G Q P E N
AGC GAC ATC GCC GTG GAG TGG GAG AGC AAT GGG CAG CCG GAG AAC
1215 1224 1233 1242 1251

N Y K T T P P V L D S D G S F
AAC TAC AAG ACC ACG CCT CCC GTG CTG GAC TCC GAC TCC TCC TTC
1260 1269 1278 1287 1296

F L Y S K L T V D K S R W Q Q
TTC CTC TAC AGC AAG CTC ACC GTG GAC AAG AGC AGG TGG CAG CAG
1305 1314 1323 1332 1341

G N V F S C S V M H E A L H N
GGG AAC GTC TTC TCA TGC TCC GTG ATG CAT GAG GCT CTG CAC AAC
1350 1359 1368 1377 1386

H Y T Q K S L S L S P G K .
CAC TAC ACG CAG AAG AGC CTC TCC CTG TCT CCG GGT AAA TGA
1395 1404 1413 1422 1431

FIG. 10B - 3

COMBINED DECLARATION AND POWER OF ATTORNEY FOR UTILITY PATENT APPLICATION	Attorney's Docket No. 012712-131

As a below-named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name;
I BELIEVE I AM THE ORIGINAL, FIRST AND SOLE INVENTOR (if only one name is listed below) OR AN ORIGINAL, FIRST AND JOINT INVENTOR (if more than one name is listed below) OF THE SUBJECT MATTER WHICH IS CLAIMED AND FOR WHICH A PATENT IS SOUGHT ON THE INVENTION ENTITLED:

MONKEY MONOCLONAL ANTIBODIES SPECIFIC TO HUMAN B7.1 AND/OR B7.2 PRIMATIZED FORMS THEREOF, PHARMACEUTICAL COMPOSITIONS CONTAINING, AND USE THEREOF AS IMMUNOSUPPRESSANTS

the specification of which

(check one) ☐ is attached hereto;
☒ was filed on June 7, 1995 as
Application No. 08/487,550
and was amended on _____ (if applicable);

I HAVE REVIEWED AND UNDERSTAND THE CONTENTS OF THE ABOVE-IDENTIFIED SPECIFICATION, INCLUDING THE CLAIMS, AS AMENDED BY ANY AMENDMENT REFERRED TO ABOVE;

I ACKNOWLEDGE THE DUTY TO DISCLOSE TO THE OFFICE ALL INFORMATION KNOWN TO ME TO BE MATERIAL TO PATENTABILITY AS DEFINED IN TITLE 37, CODE OF FEDERAL REGULATIONS, Sec. 1.56 (as amended effective March 16, 1992);

I do not know and do not believe the said invention was ever known or used in the United States of America before my or our invention thereof, or patented or described in any printed publication in any country before my or our invention thereof or more than one year prior to said application; that said invention was not in public use or on sale in the United States of America more than one year prior to said application; that said invention has not been patented or made the subject of an inventor's certificate issued before the date of said application in any country foreign to the United States of America on any application filed by me or my legal representatives or assigns more than twelve months prior to said application;

I hereby claim foreign priority benefits under Title 35, United States Code Sec. 119 and/or Sec. 365 of any foreign application(s) for patent or inventor's certificate as indicated below and have also identified below any foreign application for patent or inventor's certificate on this invention having a filing date before that of the application(s) on which priority is claimed:

COMBINED DECLARATION AND POWER OF ATTORNEY

Attorney's Docket No.
012712-131

COUNTRY/INTERNATIONAL	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED
			YES_ NO_
			YES_ NO_

I hereby appoint the following attorneys and agent(s) to prosecute said application and to transact all business in the Patent and Trademark Office connected therewith and to file, prosecute and to transact all business in connection with international applications directed to said invention:

William L. Mathis	17,337	Ralph L. Freeland, Jr.	16,110	William C. Rowland	30,888
Peter H. Smolka	15,913	Robert G. Mukai	28,531	T. Gene Dillahunty	25,423
Robert S. Swecker	19,885	George A. Hovanec, Jr.	28,223	Anthony W. Shaw	30,104
Platon N. Mandros	22,124	James A. LaBarre	28,632	Patrick C. Keane	32,858
Benton S. Duffett, Jr.	22,030	E. Joseph Gess	28,510	Bruce J. Boggs, Jr.	32,344
Joseph R. Magnone	24,239	R. Danny Huntington	27,903	William H. Benz	25,952
Norman H. Stepno	22,716	Eric H. Weisblatt	30,505	Peter K. Skiff	31,917
Ronald L. Grudziecki	24,970	James W. Peterson	26,057	Richard J. McGrath	29,195
Frederick G. Michaud, Jr.	26,003	Teresa Stanek Rea	30,427	Matthew L. Schneider	32,814
Alan E. Kopecki	25,813	Robert E. Krebs	25,885	Michael G. Savage	32,596
Regis E. Slutter	26,999	Robert M. Schulman	31,196	Gerald F. Swiss	30,113
Samuel C. Miller, III	27,360				

and: Robin L. Teskin

Address all correspondence to: **E. Joseph Gess**
Burns, Doane, Swecker & Mathis, LLP
P.O. Box 1404
Alexandria, Virginia 22313-1404

Address all telephone calls to: E. Joseph Gess at (703) 836-6620.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

FULL NAME OF SOLE OR FIRST INVENTOR	SIGNATURE	DATE
Darrell R. ANDERSON	Darrell R. Anderson	12-18-97
RESIDENCE	CITIZENSHIP	
Escondido, California 92029	USA	
POST OFFICE ADDRESS		
29246 Lawrence Welk Lane, Escondido, CA 92029		
FULL NAME OF SECOND JOINT INVENTOR, IF ANY	SIGNATURE	DATE
Peter BRAMS	Peter Brams	12-18-97
RESIDENCE	CITIZENSHIP	
San Diego, California 92116	Danish	
POST OFFICE ADDRESS		
4303 Proctor Place, San Diego, CA 92116		
FULL NAME OF THIRD JOINT INVENTOR, IF ANY	SIGNATURE	DATE
Nabil HANNA	Nabil Hanna	12-18-97
RESIDENCE	CITIZENSHIP	
Rancho Santa Fe, California 92067	USA	
POST OFFICE ADDRESS		
16016 Camino Deliciada, Rancho Santa Fe, CA 92067		

(1/96)

FULL NAME OF FOURTH JOINT INVENTOR, IF ANY	SIGNATURE	DATE
William S. SHESTOWSKY	William Shestowsky	12-18-97
RESIDENCE	CITIZENSHIP	
San Diego, California 92109	Canadian	
POST OFFICE ADDRESS		
1155 Thomas Avenue, San Diego, CA 92109		
FULL NAME OF FIFTH JOINT INVENTOR, IF ANY	SIGNATURE	DATE
Cheryl HEARD	Cheryl Heard	12-18-97
RESIDENCE	CITIZENSHIP	
1225 Via Montoro, Encinitas, CA 92024	USA	
POST OFFICE ADDRESS		
1225 Via Montoro, Encinitas, CA 92024		
FULL NAME OF SIXTH JOINT INVENTOR, IF ANY	SIGNATURE	DATE
RESIDENCE	CITIZENSHIP	
POST OFFICE ADDRESS		
FULL NAME OF SEVENTH JOINT INVENTOR, IF ANY	SIGNATURE	DATE
RESIDENCE	CITIZENSHIP	
POST OFFICE ADDRESS		
FULL NAME OF EIGHTH JOINT INVENTOR, IF ANY	SIGNATURE	DATE
RESIDENCE	CITIZENSHIP	
POST OFFICE ADDRESS		
FULL NAME OF NINTH JOINT INVENTOR, IF ANY	SIGNATURE	DATE
RESIDENCE	CITIZENSHIP	
POST OFFICE ADDRESS		
FULL NAME OF TENTH JOINT INVENTOR, IF ANY	SIGNATURE	DATE
RESIDENCE	CITIZENSHIP	
POST OFFICE ADDRESS		
FULL NAME OF ELEVENTH JOINT INVENTOR, IF ANY	SIGNATURE	DATE
RESIDENCE	CITIZENSHIP	
POST OFFICE ADDRESS		
FULL NAME OF TWELFTH JOINT INVENTOR, IF ANY	SIGNATURE	DATE
RESIDENCE	CITIZENSHIP	
POST OFFICE ADDRESS		

(1/99)

SEQUENCE LISTING

(1) GENERAL INFORMATION:

(i) APPLICANT: Anderson, Darrell R.

(ii) TITLE OF INVENTION: "MONKEY MONOCLONAL ANTIBODIES SPECIFIC TO HUMAN B7.1 AND/OR B7.2 PRIMATIZED FORMS THEREOF, PHARMACEUTIAL COMPOSITIONS CONTAINING, AND USE THEREOF AS IMMUNOSUPPRESANTS"

(iii) NUMBER OF SEQUENCES: 12

(iv) CORRESPONDENCE ADDRESS:
(A) ADDRESSEE: BURNS, DOANE, SWECKER & MATHIS
(B) STREET: 699 Prince Street
(C) CITY: Alexandria
(D) STATE: VA
(E) COUNTRY: USA
(F) ZIP: 22314

(v) COMPUTER READABLE FORM:
(A) MEDIUM TYPE: Floppy disk
(B) COMPUTER: IBM PC compatible
(C) OPERATING SYSTEM: PC-DOS/MS-DOS
(D) SOFTWARE: PatentIn Release #1.0, Version #1.30

(vi) CURRENT APPLICATION DATA:
(A) APPLICATION NUMBER: US 08/487,550
(B) FILING DATE: 07-JUN-1995
(C) CLASSIFICATION:

(viii) ATTORNEY/AGENT INFORMATION:
(A) NAME: Teskin, Robin L.
(B) REGISTRATION NUMBER: 35,030
(C) REFERENCE/DOCKET NUMBER: 012712-131

(ix) TELECOMMUNICATION INFORMATION:
(A) TELEPHONE: 703 836 6620
(B) TELEFAX: 703 836 2021

(2) INFORMATION FOR SEQ ID NO:1:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 705 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: not relevant
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(ix) FEATURE:

(A) NAME/KEY: CDS
(B) LOCATION: 1..705

(ix) FEATURE:
(A) NAME/KEY: mat_peptide
(B) LOCATION: 1..705

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

```
ATG AGG GTC CCC GCT CAG CTC CTG GGG CTC CTG CTG CTC TGG CTC CCA      48
Met Arg Val Pro Ala Gln Leu Leu Gly Leu Leu Leu Leu Trp Leu Pro
  1               5                  10                  15

GGT GCA CGA TGT GCC TAT GAA CTG ACT CAG CCA CCC TCG GTG TCA GTG      96
Gly Ala Arg Cys Ala Tyr Glu Leu Thr Gln Pro Pro Ser Val Ser Val
             20                  25                  30

TCC CCA GGA CAG ACG GCC AGG ATC ACC TGT GGG GGA GAC AAC AGT AGA     144
Ser Pro Gly Gln Thr Ala Arg Ile Thr Cys Gly Gly Asp Asn Ser Arg
         35                  40                  45

AAT GAA TAT GTC CAC TGG TAC CAG CAG AAG CCA GCG CGG GCC CCT ATA     192
Asn Glu Tyr Val His Trp Tyr Gln Gln Lys Pro Ala Arg Ala Pro Ile
     50                  55                  60

CTG GTC ATC TAT GAT GAT AGT GAC CGG CCC TCA GGG ATC CCT GAG CGA     240
Leu Val Ile Tyr Asp Asp Ser Asp Arg Pro Ser Gly Ile Pro Glu Arg
 65                  70                  75                  80

TTC TCT GGC TCC AAA TCA GGG AAC ACC GCC ACC CTG ACC ATC AAC GGG     288
Phe Ser Gly Ser Lys Ser Gly Asn Thr Ala Thr Leu Thr Ile Asn Gly
                 85                  90                  95

GTC GAG GCC GGG GAT GAG GCT GAC TAT TAC TGT CAG GTG TGG GAC AGG     336
Val Glu Ala Gly Asp Glu Ala Asp Tyr Tyr Cys Gln Val Trp Asp Arg
            100                 105                 110

GCT AGT GAT CAT CCG GTC TTC GGA GGA GGG ACC CGG GTG ACC GTC CTA     384
Ala Ser Asp His Pro Val Phe Gly Gly Gly Thr Arg Val Thr Val Leu
        115                 120                 125

GGT CAG CCC AAG GCT GCC CCC TCG GTC ACT CTG TTC CCG CCC TCC TCT     432
Gly Gln Pro Lys Ala Ala Pro Ser Val Thr Leu Phe Pro Pro Ser Ser
    130                 135                 140

GAG GAG CTT CAA GCC AAC AAG GCC ACA CTG GTG TGT CTC ATA AGT GAC     480
Glu Glu Leu Gln Ala Asn Lys Ala Thr Leu Val Cys Leu Ile Ser Asp
145                 150                 155                 160

TTC TAC CCG GGA GCC GTG ACA GTG GCC TGG AAG GCA GAT AGC AGC CCC     528
Phe Tyr Pro Gly Ala Val Thr Val Ala Trp Lys Ala Asp Ser Ser Pro
                165                 170                 175

GTC AAG GCG GGA GTG GAG ACC ACC ACA CCC TCC AAA CAA AGC AAC AAC     576
Val Lys Ala Gly Val Glu Thr Thr Thr Pro Ser Lys Gln Ser Asn Asn
```

```
          180                 185                 190

AAG TAC GCG GCC AGC AGC TAC CTG AGC CTG ACG CCT GAG CAG TGG AAG      624
Lys Tyr Ala Ala Ser Ser Tyr Leu Ser Leu Thr Pro Glu Gln Trp Lys
        195                 200                 205

TCC CAC AGA AGC TAC AGC TGC CAG GTC ACG CAT GAA GGG AGC ACC GTG      672
Ser His Arg Ser Tyr Ser Cys Gln Val Thr His Glu Gly Ser Thr Val
    210                 215                 220

GAG AAG ACA GTG GCC CCT ACA GAA TGT TCA TGA                          705
Glu Lys Thr Val Ala Pro Thr Glu Cys Ser  *
225                 230                 235
```

(2) INFORMATION FOR SEQ ID NO:2:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 235 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

```
Met Arg Val Pro Ala Gln Leu Leu Gly Leu Leu Leu Leu Trp Leu Pro
  1               5                  10                  15

Gly Ala Arg Cys Ala Tyr Glu Leu Thr Gln Pro Pro Ser Val Ser Val
            20                  25                  30

Ser Pro Gly Gln Thr Ala Arg Ile Thr Cys Gly Gly Asp Asn Ser Arg
        35                  40                  45

Asn Glu Tyr Val His Trp Tyr Gln Gln Lys Pro Ala Arg Ala Pro Ile
    50                  55                  60

Leu Val Ile Tyr Asp Asp Ser Asp Arg Pro Ser Gly Ile Pro Glu Arg
65                  70                  75                  80

Phe Ser Gly Ser Lys Ser Gly Asn Thr Ala Thr Leu Thr Ile Asn Gly
                85                  90                  95

Val Glu Ala Gly Asp Glu Ala Asp Tyr Tyr Cys Gln Val Trp Asp Arg
            100                 105                 110

Ala Ser Asp His Pro Val Phe Gly Gly Gly Thr Arg Val Thr Val Leu
        115                 120                 125

Gly Gln Pro Lys Ala Ala Pro Ser Val Thr Leu Phe Pro Pro Ser Ser
    130                 135                 140

Glu Glu Leu Gln Ala Asn Lys Ala Thr Leu Val Cys Leu Ile Ser Asp
145                 150                 155                 160
```

Phe Tyr Pro Gly Ala Val Thr Val Ala Trp Lys Ala Asp Ser Ser Pro
165 170 175

Val Lys Ala Gly Val Glu Thr Thr Thr Pro Ser Lys Gln Ser Asn Asn
180 185 190

Lys Tyr Ala Ala Ser Ser Tyr Leu Ser Leu Thr Pro Glu Gln Trp Lys
195 200 205

Ser His Arg Ser Tyr Ser Cys Gln Val Thr His Glu Gly Ser Thr Val
210 215 220

Glu Lys Thr Val Ala Pro Thr Glu Cys Ser *
225 230 235

(2) INFORMATION FOR SEQ ID NO:3:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1431 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: not relevant
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 1..1431

(ix) FEATURE:
(A) NAME/KEY: mat_peptide
(B) LOCATION: 1..1431

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

ATG AAA CAC CTG TGG TTC TTC CTC CTC CTG GTG GCA GCT CCC AGA TGG 48
Met Lys His Leu Trp Phe Phe Leu Leu Leu Val Ala Ala Pro Arg Trp
1 5 10 15

GTC CTG TCC CAG GTG AAG CTG CAG CAG TGG GGC GAA GGA CTT CTG CAG 96
Val Leu Ser Gln Val Lys Leu Gln Gln Trp Gly Glu Gly Leu Leu Gln
20 25 30

CCT TCG GAG ACC CTG TCC CGC ACC TGC GTT GTC TCT GGT GGC TCC ATC 144
Pro Ser Glu Thr Leu Ser Arg Thr Cys Val Val Ser Gly Gly Ser Ile
35 40 45

AGC GGT TAC TAC TAC TGG ACC TGG ATC CGC CAG ACC CCA GGG AGG GGA 192
Ser Gly Tyr Tyr Tyr Trp Thr Trp Ile Arg Gln Thr Pro Gly Arg Gly
50 55 60

CTG GAG TGG ATT GGC CAT ATT TAT GGT AAT GGT GCG ACC ACC AAC TAC 240
Leu Glu Trp Ile Gly His Ile Tyr Gly Asn Gly Ala Thr Thr Asn Tyr
65 70 75 80

```
AAT CCC TCC CTC AAG AGT CGA GTC ACC ATT TCA AAA GAC ACG TCC AAG      288
Asn Pro Ser Leu Lys Ser Arg Val Thr Ile Ser Lys Asp Thr Ser Lys
                85                  90                  95

AAC CAG TTC TTC CTG AAC TTG AAT TCT GTG ACC GAC GCG GAC ACG GCC      336
Asn Gln Phe Phe Leu Asn Leu Asn Ser Val Thr Asp Ala Asp Thr Ala
            100                 105                 110

GTC TAT TAC TGT GCG AGA GGC CCT CGC CCT GAT TGC ACA ACC ATT TGT      384
Val Tyr Tyr Cys Ala Arg Gly Pro Arg Pro Asp Cys Thr Thr Ile Cys
        115                 120                 125

TAT GGC GGC TGG GTC GAT GTC TGG GGC CCG GGA GAC CTG GTC ACC GTC      432
Tyr Gly Gly Trp Val Asp Val Trp Gly Pro Gly Asp Leu Val Thr Val
    130                 135                 140

TCC TCA GCT AGC ACC AAG GGC CCA TCG GTC TTC CCC CTG GCA CCC TCC      480
Ser Ser Ala Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala Pro Ser
145                 150                 155                 160

TCC AAG AGC ACC TCT GGG GGC ACA GCG GCC CTG GGC TGC CTG GTC AAG      528
Ser Lys Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu Val Lys
                165                 170                 175

GAC TAC TTC CCC GAA CCG GTG ACG GTG TCG TGG AAC TCA GGC GCC CTG      576
Asp Tyr Phe Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly Ala Leu
            180                 185                 190

ACC AGC GGC GTG CAC ACC TTC CCG GCT GTC CTA CAG TCC TCA GGA CTC      624
Thr Ser Gly Val His Thr Phe Pro Ala Val Leu Gln Ser Ser Gly Leu
        195                 200                 205

TAC TCC CTC AGC AGC GTG GTG ACC GTG CCC TCC AGC AGC TTG GGC ACC      672
Tyr Ser Leu Ser Ser Val Val Thr Val Pro Ser Ser Ser Leu Gly Thr
    210                 215                 220

CAG ACC TAC ATC TGC AAC GTG AAT CAC AAG CCC AGC AAC ACC AAG GTG      720
Gln Thr Tyr Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr Lys Val
225                 230                 235                 240

GAC AAG AAA GCA GAG CCC AAA TCT TGT GAC AAA ACT CAC ACA TGC CCA      768
Asp Lys Lys Ala Glu Pro Lys Ser Cys Asp Lys Thr His Thr Cys Pro
                245                 250                 255

CCG TGC CCA GCA CCT GAA CTC CTG GGG GGA CCG TCA GTC TTC CTC TTC      816
Pro Cys Pro Ala Pro Glu Leu Leu Gly Gly Pro Ser Val Phe Leu Phe
            260                 265                 270

CCC CCA AAA CCC AAG GAC ACC CTC ATG ATC TCC CGG ACC CCT GAG GTC      864
Pro Pro Lys Pro Lys Asp Thr Leu Met Ile Ser Arg Thr Pro Glu Val
        275                 280                 285

ACA TGC GTG GTG GTG GAC GTG AGC CAC GAA GAC CCT GAG GTC AAG TTC      912
Thr Cys Val Val Val Asp Val Ser His Glu Asp Pro Glu Val Lys Phe
    290                 295                 300
```

AAC TGG TAC GTG GAC GGC GTG GAG GTG CAT AAT GCC AAG ACA AAG CCG 960
Asn Trp Tyr Val Asp Gly Val Glu Val His Asn Ala Lys Thr Lys Pro
305 310 315 320

CGG GAG GAG CAG TAC AAC AGC ACG TAC CGT GTG GTC AGC GTC CTC ACC 1008
Arg Glu Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val Ser Val Leu Thr
325 330 335

GTC CTG CAC CAG GAC TGG CTG AAT GGC AAG GAG TAC AAG TGC AAG GTC 1056
Val Leu His Gln Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys Lys Val
340 345 350

TCC AAC AAA GCC CTC CCA GCC CCC ATC GAG AAA ACC ATC TCC AAA GCC 1104
Ser Asn Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser Lys Ala
355 360 365

AAA GGG CAG CCC CGA GAA CCA CAG GTG TAC ACC CTG CCC CCA TCC CGG 1152
Lys Gly Gln Pro Arg Glu Pro Gln Val Tyr Thr Leu Pro Pro Ser Arg
370 375 380

GAT GAG CTG ACC AAG AAC CAG GTC AGC CTG ACC TGC CTG GTC AAA GGC 1200
Asp Glu Leu Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val Lys Gly
385 390 395 400

TTC TAT CCC AGC GAC ATC GCC GTG GAG TGG GAG AGC AAT GGG CAG CCG 1248
Phe Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gly Gln Pro
405 410 415

GAG AAC AAC TAC AAG ACC ACG CCT CCC GTG CTG GAC TCC GAC GGC TCC 1296
Glu Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp Gly Ser
420 425 430

TTC TTC CTC TAC AGC AAG CTC ACC GTG GAC AAG AGC AGG TGG CAG CAG 1344
Phe Phe Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser Arg Trp Gln Gln
435 440 445

GGG AAC GTC TTC TCA TGC TCC GTG ATG CAT GAG GCT CTG CAC AAC CAC 1392
Gly Asn Val Phe Ser Cys Ser Val Met His Glu Ala Leu His Asn His
450 455 460

TAC ACG CAG AAG AGC CTC TCC CTG TCT CCG GGT AAA TGA 1431
Tyr Thr Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys *
465 470 475

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 477 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

Met Lys His Leu Trp Phe Phe Leu Leu Leu Val Ala Ala Pro Arg Trp
1 5 10 15

Val Leu Ser Gln Val Lys Leu Gln Gln Trp Gly Glu Gly Leu Leu Gln
20 25 30

Pro Ser Glu Thr Leu Ser Arg Thr Cys Val Val Ser Gly Gly Ser Ile
35 40 45

Ser Gly Tyr Tyr Tyr Trp Thr Trp Ile Arg Gln Thr Pro Gly Arg Gly
50 55 60

Leu Glu Trp Ile Gly His Ile Tyr Gly Asn Gly Ala Thr Thr Asn Tyr
65 70 75 80

Asn Pro Ser Leu Lys Ser Arg Val Thr Ile Ser Lys Asp Thr Ser Lys
85 90 95

Asn Gln Phe Phe Leu Asn Leu Asn Ser Val Thr Asp Ala Asp Thr Ala
100 105 110

Val Tyr Tyr Cys Ala Arg Gly Pro Arg Pro Asp Cys Thr Thr Ile Cys
115 120 125

Tyr Gly Gly Trp Val Asp Val Trp Gly Pro Gly Asp Leu Val Thr Val
130 135 140

Ser Ser Ala Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala Pro Ser
145 150 155 160

Ser Lys Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu Val Lys
165 170 175

Asp Tyr Phe Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly Ala Leu
180 185 190

Thr Ser Gly Val His Thr Phe Pro Ala Val Leu Gln Ser Ser Gly Leu
195 200 205

Tyr Ser Leu Ser Ser Val Val Thr Val Pro Ser Ser Ser Leu Gly Thr
210 215 220

Gln Thr Tyr Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr Lys Val
225 230 235 240

Asp Lys Lys Ala Glu Pro Lys Ser Cys Asp Lys Thr His Thr Cys Pro
245 250 255

Pro Cys Pro Ala Pro Glu Leu Leu Gly Gly Pro Ser Val Phe Leu Phe
260 265 270

Pro Pro Lys Pro Lys Asp Thr Leu Met Ile Ser Arg Thr Pro Glu Val
275 280 285

Thr Cys Val Val Val Asp Val Ser His Glu Asp Pro Glu Val Lys Phe
290 295 300

Asn Trp Tyr Val Asp Gly Val Glu Val His Asn Ala Lys Thr Lys Pro
305   310   315   320

Arg Glu Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val Ser Val Leu Thr
                325   330   335

Val Leu His Gln Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys Lys Val
            340   345   350

Ser Asn Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser Lys Ala
        355   360   365

Lys Gly Gln Pro Arg Glu Pro Gln Val Tyr Thr Leu Pro Pro Ser Arg
    370   375   380

Asp Glu Leu Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val Lys Gly
385   390   395   400

Phe Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gly Gln Pro
                405   410   415

Glu Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp Gly Ser
            420   425   430

Phe Phe Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser Arg Trp Gln Gln
        435   440   445

Gly Asn Val Phe Ser Cys Ser Val Met His Glu Ala Leu His Asn His
    450   455   460

Tyr Thr Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys *
465   470   475

(2) INFORMATION FOR SEQ ID NO:5:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 720 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: not relevant
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 1..720

(ix) FEATURE:
(A) NAME/KEY: mat_peptide
(B) LOCATION: 1..720

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:5:

ATG AGC CTC CCT GCT CAG CTC CTC GGG CTG CTA TTG CTC TGC GTC CCC 48

```
Met Ser Leu Pro Ala Gln Leu Leu Gly Leu Leu Leu Leu Cys Val Pro
 1               5                  10                  15

GGG TCC AGT GGG GAA GTT GTG ATG ACT CAG TCT CCA CTG TCC CTT CCC      96
Gly Ser Ser Gly Glu Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro
             20                  25                  30

ATC ACA CCT GGA GAG CCG GCC TCC ATC TCC TGT AGG TCT AGT CAA AGC     144
Ile Thr Pro Gly Glu Pro Ala Ser Ile Ser Cys Arg Ser Ser Gln Ser
         35                  40                  45

CTT AAA CAC AGT AAT GGA GAC ACC TTC CTG AGT TGG TAT CAG CAG AAG     192
Leu Lys His Ser Asn Gly Asp Thr Phe Leu Ser Trp Tyr Gln Gln Lys
     50                  55                  60

CCA GGC CAA CCT CCA AGG CTC CTG ATT TAT AAG GTT TCT AAC CGG GAC     240
Pro Gly Gln Pro Pro Arg Leu Leu Ile Tyr Lys Val Ser Asn Arg Asp
 65                  70                  75                  80

TCT GGG GTC CCA GAC AGA TTC AGC GGC AGT GGG GCA GGG ACA GAT TTC     288
Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ala Gly Thr Asp Phe
                 85                  90                  95

ACA CTG AAA ATC AGC GCA GTG GAG GCT GAA GAT GTT GGG GTT TAT TTC     336
Thr Leu Lys Ile Ser Ala Val Glu Ala Glu Asp Val Gly Val Tyr Phe
            100                 105                 110

TGC GGG CAA GGT ACA AGG ACT CCT CCC ACT TTC GGC GGA GGG ACC AAG     384
Cys Gly Gln Gly Thr Arg Thr Pro Pro Thr Phe Gly Gly Gly Thr Lys
        115                 120                 125

GTG GAA ATC AAA CGT ACG GTG GCT GCA CCA TCT GTC TTC ATC TTC CCG     432
Val Glu Ile Lys Arg Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro
    130                 135                 140

CCA TCT GAT GAG CAG TTG AAA TCT GGA ACT GCC TCT GTT GTG TGC CTG     480
Pro Ser Asp Glu Gln Leu Lys Ser Gly Thr Ala Ser Val Val Cys Leu
145                 150                 155                 160

CTG AAT AAC TTC TAT CCC AGA GAG GCC AAA GTA CAG TGG AAG GTG GAT     528
Leu Asn Asn Phe Tyr Pro Arg Glu Ala Lys Val Gln Trp Lys Val Asp
                165                 170                 175

AAC GCC CTC CAA TCG GGT AAC TCC CAG GAG AGT GTC ACA GAG CAG GAC     576
Asn Ala Leu Gln Ser Gly Asn Ser Gln Glu Ser Val Thr Glu Gln Asp
            180                 185                 190

AGC AAG GAC AGC ACC TAC AGC CTC AGC AGC ACC CTG ACG CTG AGC AAA     624
Ser Lys Asp Ser Thr Tyr Ser Leu Ser Ser Thr Leu Thr Leu Ser Lys
        195                 200                 205

GCA GAC TAC GAG AAA CAC AAA GTC TAC GCC TGC GAA GTC ACC CAT CAG     672
Ala Asp Tyr Glu Lys His Lys Val Tyr Ala Cys Glu Val Thr His Gln
    210                 215                 220

GGC CTG AGC TCG CCC GTC ACA AAG AGC TTC AAC AGG GGA GAG TGT TGA     720
```

```
Gly Leu Ser Ser Pro Val Thr Lys Ser Phe Asn Arg Gly Glu Cys  *
225                 230                 235                 240
```

(2) INFORMATION FOR SEQ ID NO:6:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 240 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:6:

```
Met Ser Leu Pro Ala Gln Leu Leu Gly Leu Leu Leu Leu Cys Val Pro
 1               5                  10                  15

Gly Ser Ser Gly Glu Val Val Met Thr Gln Ser Pro Leu Ser Leu Pro
            20                  25                  30

Ile Thr Pro Gly Glu Pro Ala Ser Ile Ser Cys Arg Ser Ser Gln Ser
        35                  40                  45

Leu Lys His Ser Asn Gly Asp Thr Phe Leu Ser Trp Tyr Gln Gln Lys
    50                  55                  60

Pro Gly Gln Pro Pro Arg Leu Leu Ile Tyr Lys Val Ser Asn Arg Asp
65                  70                  75                  80

Ser Gly Val Pro Asp Arg Phe Ser Gly Ser Gly Ala Gly Thr Asp Phe
                85                  90                  95

Thr Leu Lys Ile Ser Ala Val Glu Ala Glu Asp Val Gly Val Tyr Phe
            100                 105                 110

Cys Gly Gln Gly Thr Arg Thr Pro Pro Thr Phe Gly Gly Gly Thr Lys
        115                 120                 125

Val Glu Ile Lys Arg Thr Val Ala Ala Pro Ser Val Phe Ile Phe Pro
    130                 135                 140

Pro Ser Asp Glu Gln Leu Lys Ser Gly Thr Ala Ser Val Val Cys Leu
145                 150                 155                 160

Leu Asn Asn Phe Tyr Pro Arg Glu Ala Lys Val Gln Trp Lys Val Asp
                165                 170                 175

Asn Ala Leu Gln Ser Gly Asn Ser Gln Glu Ser Val Thr Glu Gln Asp
            180                 185                 190

Ser Lys Asp Ser Thr Tyr Ser Leu Ser Ser Thr Leu Thr Leu Ser Lys
        195                 200                 205

Ala Asp Tyr Glu Lys His Lys Val Tyr Ala Cys Glu Val Thr His Gln
    210                 215                 220
```

Gly Leu Ser Ser Pro Val Thr Lys Ser Phe Asn Arg Gly Glu Cys *
225 230 235 240

(2) INFORMATION FOR SEQ ID NO:7:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1437 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: not relevant
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 1..1437

(ix) FEATURE:
(A) NAME/KEY: mat_peptide
(B) LOCATION: 1..1437

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

ATG GGT TGG AGC CTC ATC TTG CTC TTC CTT GTC GCT GTT GCT ACG CGT 48
Met Gly Trp Ser Leu Ile Leu Leu Phe Leu Val Ala Val Ala Thr Arg
1 5 10 15

GTC CAG TGT GAG GTG CAA CTG GTG GAG TCT GGG GGA GGC TTG GTC CAG 96
Val Gln Cys Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Val Gln
20 25 30

CCT GGC GGG TCC CTG AGA GTC TCC TGT GCA GTC TCT GGA TTC ACC TTC 144
Pro Gly Gly Ser Leu Arg Val Ser Cys Ala Val Ser Gly Phe Thr Phe
35 40 45

AGT GAC CAC TAC ATG TAT TGG TTC CGC CAG GCT CCA GGG AAG GGG CCG 192
Ser Asp His Tyr Met Tyr Trp Phe Arg Gln Ala Pro Gly Lys Gly Pro
50 55 60

GAA TGG GTA GGT TTC ATT AGA AAC AAA CCG AAC GGT GGG ACA ACA GAA 240
Glu Trp Val Gly Phe Ile Arg Asn Lys Pro Asn Gly Gly Thr Thr Glu
65 70 75 80

TAC GCC GCG TCT GTG AAA GAC AGA TTC ACC ATC TCC AGA GAT GAT TCC 288
Tyr Ala Ala Ser Val Lys Asp Arg Phe Thr Ile Ser Arg Asp Asp Ser
85 90 95

AAA AGC ATC GCC TAT CTG CAA ATG AGC AGC CTG AAA ATC GAG GAC ACG 336
Lys Ser Ile Ala Tyr Leu Gln Met Ser Ser Leu Lys Ile Glu Asp Thr
100 105 110

GCC GTC TAT TAC TGT ACT ACA TCC TAC ATT TCA CAT TGT CGG GGT GGT 384
Ala Val Tyr Tyr Cys Thr Thr Ser Tyr Ile Ser His Cys Arg Gly Gly

115 120 125

GTC TGC TAT GGA GGT TAC TTC GAA TTC TGG GGC CAG GGC GCC CTG GTC 432
Val Cys Tyr Gly Gly Tyr Phe Glu Phe Trp Gly Gln Gly Ala Leu Val
130 135 140

ACC GTC TCC TCA GCT AGC ACC AAG GGC CCA TCG GTC TTC CCC CTG GCA 480
Thr Val Ser Ser Ala Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala
145 150 155 160

CCC TCC TCC AAG AGC ACC TCT GGG GGC ACA GCG GCC CTG GGC TGC CTG 528
Pro Ser Ser Lys Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu
165 170 175

GTC AAG GAC TAC TTC CCC GAA CCG GTG ACG GTG TCG TGG AAC TCA GGC 576
Val Lys Asp Tyr Phe Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly
180 185 190

GCC CTG ACC AGC GGC GTG CAC ACC TTC CCG GCT GTC CTA CAG TCC TCA 624
Ala Leu Thr Ser Gly Val His Thr Phe Pro Ala Val Leu Gln Ser Ser
195 200 205

GGA CTC TAC TCC CTC AGC AGC GTG GTG ACC GTG CCC TCC AGC AGC TTG 672
Gly Leu Tyr Ser Leu Ser Ser Val Val Thr Val Pro Ser Ser Ser Leu
210 215 220

GGC ACC CAG ACC TAC ATC TGC AAC GTG AAT CAC AAG CCC AGC AAC ACC 720
Gly Thr Gln Thr Tyr Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr
225 230 235 240

AAG GTG GAC AAG AAA GCA GAG CCC AAA TCT TGT GAC AAA ACT CAC ACA 768
Lys Val Asp Lys Lys Ala Glu Pro Lys Ser Cys Asp Lys Thr His Thr
245 250 255

TGC CCA CCG TGC CCA GCA CCT GAA CTC CTG GGG GGA CCG TCA GTC TTC 816
Cys Pro Pro Cys Pro Ala Pro Glu Leu Leu Gly Gly Pro Ser Val Phe
260 265 270

CTC TTC CCC CCA AAA CCC AAG GAC ACC CTC ATG ATC TCC CGG ACC CCT 864
Leu Phe Pro Pro Lys Pro Lys Asp Thr Leu Met Ile Ser Arg Thr Pro
275 280 285

GAG GTC ACA TGC GTG GTG GTG GAC GTG AGC CAC GAA GAC CCT GAG GTC 912
Glu Val Thr Cys Val Val Val Asp Val Ser His Glu Asp Pro Glu Val
290 295 300

AAG TTC AAC TGG TAC GTG GAC GGC GTG GAG GTG CAT AAT GCC AAG ACA 960
Lys Phe Asn Trp Tyr Val Asp Gly Val Glu Val His Asn Ala Lys Thr
305 310 315 320

AAG CCG CGG GAG GAG CAG TAC AAC AGC ACG TAC CGT GTG GTC AGC GTC 1008
Lys Pro Arg Glu Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val Ser Val
325 330 335

CTC ACC GTC CTG CAC CAG GAC TGG CTG AAT GGC AAG GAG TAC AAG TGC 1056
Leu Thr Val Leu His Gln Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys

```
            340                   345                  350

AAG GTC TCC AAC AAA GCC CTC CCA GCC CCC ATC GAG AAA ACC ATC TCC      1104
Lys Val Ser Asn Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser
        355                 360                 365

AAA GCC AAA GGG CAG CCC CGA GAA CCA CAG GTG TAC ACC CTG CCC CCA      1152
Lys Ala Lys Gly Gln Pro Arg Glu Pro Gln Val Tyr Thr Leu Pro Pro
    370                 375                 380

TCC CGG GAT GAG CTG ACC AAG AAC CAG GTC AGC CTG ACC TGC CTG GTC      1200
Ser Arg Asp Glu Leu Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val
385                 390                 395                 400

AAA GGC TTC TAT CCC AGC GAC ATC GCC GTG GAG TGG GAG AGC AAT GGG      1248
Lys Gly Phe Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gly
                405                 410                 415

CAG CCG GAG AAC AAC TAC AAG ACC ACG CCT CCC GTG CTG GAC TCC GAC      1296
Gln Pro Glu Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp
            420                 425                 430

GGC TCC TTC TTC CTC TAC AGC AAG CTC ACC GTG GAC AAG AGC AGG TGG      1344
Gly Ser Phe Phe Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser Arg Trp
        435                 440                 445

CAG CAG GGG AAC GTC TTC TCA TGC TCC GTG ATG CAT GAG GCT CTG CAC      1392
Gln Gln Gly Asn Val Phe Ser Cys Ser Val Met His Glu Ala Leu His
    450                 455                 460

AAC CAC TAC ACG CAG AAG AGC CTC TCC CTG TCT CCG GGT AAA TGA          1437
Asn His Tyr Thr Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys  *
465                 470                 475
```

(2) INFORMATION FOR SEQ ID NO:8:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 479 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

```
Met Gly Trp Ser Leu Ile Leu Leu Phe Leu Val Ala Val Ala Thr Arg
 1               5                  10                  15

Val Gln Cys Glu Val Gln Leu Val Glu Ser Gly Gly Gly Leu Val Gln
            20                  25                  30

Pro Gly Gly Ser Leu Arg Val Ser Cys Ala Val Ser Gly Phe Thr Phe
        35                  40                  45

Ser Asp His Tyr Met Tyr Trp Phe Arg Gln Ala Pro Gly Lys Gly Pro
```

```
    50                  55                  60

Glu Trp Val Gly Phe Ile Arg Asn Lys Pro Asn Gly Gly Thr Thr Glu
65                  70                  75                  80

Tyr Ala Ala Ser Val Lys Asp Arg Phe Thr Ile Ser Arg Asp Asp Ser
                85                  90                  95

Lys Ser Ile Ala Tyr Leu Gln Met Ser Ser Leu Lys Ile Glu Asp Thr
            100                 105                 110

Ala Val Tyr Tyr Cys Thr Thr Ser Tyr Ile Ser His Cys Arg Gly Gly
        115                 120                 125

Val Cys Tyr Gly Gly Tyr Phe Glu Phe Trp Gly Gln Gly Ala Leu Val
    130                 135                 140

Thr Val Ser Ser Ala Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala
145                 150                 155                 160

Pro Ser Ser Lys Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu
                165                 170                 175

Val Lys Asp Tyr Phe Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly
            180                 185                 190

Ala Leu Thr Ser Gly Val His Thr Phe Pro Ala Val Leu Gln Ser Ser
        195                 200                 205

Gly Leu Tyr Ser Leu Ser Ser Val Val Thr Val Pro Ser Ser Ser Leu
    210                 215                 220

Gly Thr Gln Thr Tyr Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr
225                 230                 235                 240

Lys Val Asp Lys Lys Ala Glu Pro Lys Ser Cys Asp Lys Thr His Thr
                245                 250                 255

Cys Pro Pro Cys Pro Ala Pro Glu Leu Leu Gly Gly Pro Ser Val Phe
            260                 265                 270

Leu Phe Pro Pro Lys Pro Lys Asp Thr Leu Met Ile Ser Arg Thr Pro
        275                 280                 285

Glu Val Thr Cys Val Val Val Asp Val Ser His Glu Asp Pro Glu Val
    290                 295                 300

Lys Phe Asn Trp Tyr Val Asp Gly Val Glu Val His Asn Ala Lys Thr
305                 310                 315                 320

Lys Pro Arg Glu Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val Ser Val
                325                 330                 335

Leu Thr Val Leu His Gln Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys
            340                 345                 350
```

Lys Val Ser Asn Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser
355 360 365

Lys Ala Lys Gly Gln Pro Arg Glu Pro Gln Val Tyr Thr Leu Pro Pro
370 375 380

Ser Arg Asp Glu Leu Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val
385 390 395 400

Lys Gly Phe Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gly
405 410 415

Gln Pro Glu Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp
420 425 430

Gly Ser Phe Phe Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser Arg Trp
435 440 445

Gln Gln Gly Asn Val Phe Ser Cys Ser Val Met His Glu Ala Leu His
450 455 460

Asn His Tyr Thr Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys *
465 470 475

(2) INFORMATION FOR SEQ ID NO:9:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 711 base pairs
(B) TYPE: nucleic acid
(C) STRANDEDNESS: not relevant
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 1..711

(ix) FEATURE:
(A) NAME/KEY: mat_peptide
(B) LOCATION: 1..711

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

ATG AGG GTC CCC GCT CAG CTC CTG GGG CTC CTG CTG CTC TGG CTC CCA 48
Met Arg Val Pro Ala Gln Leu Leu Gly Leu Leu Leu Leu Trp Leu Pro
1 5 10 15

GGT GCA CGA TGT GAG TCT GTC CTG ACA CAG CCG CCC TCA GTG TCT GGG 96
Gly Ala Arg Cys Glu Ser Val Leu Thr Gln Pro Pro Ser Val Ser Gly
20 25 30

GCC CCA GGG CAG AAG GTC ACC ATC TCG TGC ACT GGG AGC ACC TCC AAC 144
Ala Pro Gly Gln Lys Val Thr Ile Ser Cys Thr Gly Ser Thr Ser Asn

35 40 45

ATT GGA GGT TAT GAT CTA CAT TGG TAC CAG CAG CTC CCA GGA ACG GCC 192
Ile Gly Gly Tyr Asp Leu His Trp Tyr Gln Gln Leu Pro Gly Thr Ala
50 55 60

CCC AAA CTC CTC ATC TAT GAC ATT AAC AAG CGA CCC TCA GGA ATT TCT 240
Pro Lys Leu Leu Ile Tyr Asp Ile Asn Lys Arg Pro Ser Gly Ile Ser
65 70 75 80

GAC CGA TTC TCT GGC TCC AAG TCT GGT ACC GCG GCC TCC CTG GCC ATC 288
Asp Arg Phe Ser Gly Ser Lys Ser Gly Thr Ala Ala Ser Leu Ala Ile
85 90 95

ACT GGG CTC CAG ACT GAG GAT GAG GCT GAT TAT TAC TGC CAG TCC TAT 336
Thr Gly Leu Gln Thr Glu Asp Glu Ala Asp Tyr Tyr Cys Gln Ser Tyr
100 105 110

GAC AGC AGC CTG AAT GCT CAG GTA TTC GGA GGA GGG ACC CGG CTG ACC 384
Asp Ser Ser Leu Asn Ala Gln Val Phe Gly Gly Gly Thr Arg Leu Thr
115 120 125

GTC CTA GGT CAG CCC AAG GCT GCC CCC TCG GTC ACT CTG TTC CCG CCC 432
Val Leu Gly Gln Pro Lys Ala Ala Pro Ser Val Thr Leu Phe Pro Pro
130 135 140

TCC TCT GAG GAG CTT CAA GCC AAC AAG GCC ACA CTG GTG TGT CTC ATA 480
Ser Ser Glu Glu Leu Gln Ala Asn Lys Ala Thr Leu Val Cys Leu Ile
145 150 155 160

AGT GAC TTC TAC CCG GGA GCC GTG ACA GTG GCC TGG AAG GCA GAT AGC 528
Ser Asp Phe Tyr Pro Gly Ala Val Thr Val Ala Trp Lys Ala Asp Ser
165 170 175

AGC CCC GTC AAG GCG GGA GTG GAG ACC ACC ACA CCC TCC AAA CAA AGC 576
Ser Pro Val Lys Ala Gly Val Glu Thr Thr Thr Pro Ser Lys Gln Ser
180 185 190

AAC AAC AAG TAC GCG GCC AGC AGC TAC CTG AGC CTG ACG CCT GAG CAG 624
Asn Asn Lys Tyr Ala Ala Ser Ser Tyr Leu Ser Leu Thr Pro Glu Gln
195 200 205

TGG AAG TCC CAC AGA AGC TAC AGC TGC CAG GTC ACG CAT GAA GGG AGC 672
Trp Lys Ser His Arg Ser Tyr Ser Cys Gln Val Thr His Glu Gly Ser
210 215 220

ACC GTG GAG AAG ACA GTG GCC CCT ACA GAA TGT TCA TGA 711
Thr Val Glu Lys Thr Val Ala Pro Thr Glu Cys Ser *
225 230 235

(2) INFORMATION FOR SEQ ID NO:10:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 237 amino acids
(B) TYPE: amino acid

(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

```
Met Arg Val Pro Ala Gln Leu Leu Gly Leu Leu Leu Leu Trp Leu Pro
 1               5                  10                  15

Gly Ala Arg Cys Glu Ser Val Leu Thr Gln Pro Pro Ser Val Ser Gly
            20                  25                  30

Ala Pro Gly Gln Lys Val Thr Ile Ser Cys Thr Gly Ser Thr Ser Asn
        35                  40                  45

Ile Gly Gly Tyr Asp Leu His Trp Tyr Gln Gln Leu Pro Gly Thr Ala
    50                  55                  60

Pro Lys Leu Leu Ile Tyr Asp Ile Asn Lys Arg Pro Ser Gly Ile Ser
 65                  70                  75                  80

Asp Arg Phe Ser Gly Ser Lys Ser Gly Thr Ala Ala Ser Leu Ala Ile
                85                  90                  95

Thr Gly Leu Gln Thr Glu Asp Glu Ala Asp Tyr Tyr Cys Gln Ser Tyr
            100                 105                 110

Asp Ser Ser Leu Asn Ala Gln Val Phe Gly Gly Gly Thr Arg Leu Thr
        115                 120                 125

Val Leu Gly Gln Pro Lys Ala Ala Pro Ser Val Thr Leu Phe Pro Pro
    130                 135                 140

Ser Ser Glu Glu Leu Gln Ala Asn Lys Ala Thr Leu Val Cys Leu Ile
145                 150                 155                 160

Ser Asp Phe Tyr Pro Gly Ala Val Thr Val Ala Trp Lys Ala Asp Ser
                165                 170                 175

Ser Pro Val Lys Ala Gly Val Glu Thr Thr Thr Pro Ser Lys Gln Ser
            180                 185                 190

Asn Asn Lys Tyr Ala Ala Ser Ser Tyr Leu Ser Leu Thr Pro Glu Gln
        195                 200                 205

Trp Lys Ser His Arg Ser Tyr Ser Cys Gln Val Thr His Glu Gly Ser
    210                 215                 220

Thr Val Glu Lys Thr Val Ala Pro Thr Glu Cys Ser  *
225                 230                 235
```

(2) INFORMATION FOR SEQ ID NO:11:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 1431 base pairs
(B) TYPE: nucleic acid

(C) STRANDEDNESS: not relevant
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: peptide

(ix) FEATURE:
(A) NAME/KEY: CDS
(B) LOCATION: 1..1431

(ix) FEATURE:
(A) NAME/KEY: mat_peptide
(B) LOCATION: 1..1431

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

```
ATG AAA CAC CTG TGG TTC TTC CTC CTC CTG GTG GCA GCT CCC AGA TGG      48
Met Lys His Leu Trp Phe Phe Leu Leu Leu Val Ala Ala Pro Arg Trp
 1               5                  10                  15

GTC CTG TCC CAG GTG CAG CTG CAG GAG TCG GGC CCA GGA CTG GTG AAG      96
Val Leu Ser Gln Val Gln Leu Gln Glu Ser Gly Pro Gly Leu Val Lys
            20                  25                  30

CCT TCG GAG ACC CTG TCC CTC ACC TGC GCT GTC TCT GGT GGC TCC ATC     144
Pro Ser Glu Thr Leu Ser Leu Thr Cys Ala Val Ser Gly Gly Ser Ile
        35                  40                  45

AGC GGT GGT TAT GGC TGG GGC TGG ATC CGC CAG CCC CCA GGG AAG GGG     192
Ser Gly Gly Tyr Gly Trp Gly Trp Ile Arg Gln Pro Pro Gly Lys Gly
    50                  55                  60

CTG GAG TGG ATT GGG AGT TTC TAT AGT AGT AGT GGG AAC ACC TAC TAC     240
Leu Glu Trp Ile Gly Ser Phe Tyr Ser Ser Ser Gly Asn Thr Tyr Tyr
65                  70                  75                  80

AAC CCC TCC CTC AAG AGT CAA GTC ACC ATT TCA ACA GAC ACG TCC AAG     288
Asn Pro Ser Leu Lys Ser Gln Val Thr Ile Ser Thr Asp Thr Ser Lys
                85                  90                  95

AAC CAG TTC TCC CTG AAG CTG AAC TCT ATG ACC GCC GCG GAC ACG GCC     336
Asn Gln Phe Ser Leu Lys Leu Asn Ser Met Thr Ala Ala Asp Thr Ala
            100                 105                 110

GTG TAT TAC TGT GTG AGA GAT CGT CTT TTT TCA GTT GTT GGA ATG GTT     384
Val Tyr Tyr Cys Val Arg Asp Arg Leu Phe Ser Val Val Gly Met Val
        115                 120                 125

TAC AAC AAC TGG TTC GAT GTC TGG GGC CCG GGA GTC CTG GTC ACC GTC     432
Tyr Asn Asn Trp Phe Asp Val Trp Gly Pro Gly Val Leu Val Thr Val
    130                 135                 140

TCC TCA GCT AGC ACC AAG GGC CCA TCG GTC TTC CCC CTG GCA CCC TCC     480
Ser Ser Ala Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala Pro Ser
145                 150                 155                 160
```

```
TCC AAG AGC ACC TCT GGG GGC ACA GCG GCC CTG GGC TGC CTG GTC AAG      528
Ser Lys Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu Val Lys
                165                 170                 175

GAC TAC TTC CCC GAA CCG GTG ACG GTG TCG TGG AAC TCA GGC GCC CTG      576
Asp Tyr Phe Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly Ala Leu
            180                 185                 190

ACC AGC GGC GTG CAC ACC TTC CCG GCT GTC CTA CAG TCC TCA GGA CTC      624
Thr Ser Gly Val His Thr Phe Pro Ala Val Leu Gln Ser Ser Gly Leu
        195                 200                 205

TAC TCC CTC AGC AGC GTG GTG ACC GTG CCC TCC AGC AGC TTG GGC ACC      672
Tyr Ser Leu Ser Ser Val Val Thr Val Pro Ser Ser Ser Leu Gly Thr
    210                 215                 220

CAG ACC TAC ATC TGC AAC GTG AAT CAC AAG CCC AGC AAC ACC AAG GTG      720
Gln Thr Tyr Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr Lys Val
225                 230                 235                 240

GAC AAG AAA GCA GAG CCC AAA TCT TGT GAC AAA ACT CAC ACA TGC CCA      768
Asp Lys Lys Ala Glu Pro Lys Ser Cys Asp Lys Thr His Thr Cys Pro
                245                 250                 255

CCG TGC CCA GCA CCT GAA CTC CTG GGG GGA CCG TCA GTC TTC CTC TTC      816
Pro Cys Pro Ala Pro Glu Leu Leu Gly Gly Pro Ser Val Phe Leu Phe
            260                 265                 270

CCC CCA AAA CCC AAG GAC ACC CTC ATG ATC TCC CGG ACC CCT GAG GTC      864
Pro Pro Lys Pro Lys Asp Thr Leu Met Ile Ser Arg Thr Pro Glu Val
        275                 280                 285

ACA TGC GTG GTG GTG GAC GTG AGC CAC GAA GAC CCT GAG GTC AAG TTC      912
Thr Cys Val Val Val Asp Val Ser His Glu Asp Pro Glu Val Lys Phe
    290                 295                 300

AAC TGG TAC GTG GAC GGC GTG GAG GTG CAT AAT GCC AAG ACA AAG CCG      960
Asn Trp Tyr Val Asp Gly Val Glu Val His Asn Ala Lys Thr Lys Pro
305                 310                 315                 320

CGG GAG GAG CAG TAC AAC AGC ACG TAC CGT GTG GTC AGC GTC CTC ACC     1008
Arg Glu Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val Ser Val Leu Thr
                325                 330                 335

GTC CTG CAC CAG GAC TGG CTG AAT GGC AAG GAG TAC AAG TGC AAG GTC     1056
Val Leu His Gln Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys Lys Val
            340                 345                 350

TCC AAC AAA GCC CTC CCA GCC CCC ATC GAG AAA ACC ATC TCC AAA GCC     1104
Ser Asn Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser Lys Ala
        355                 360                 365

AAA GGG CAG CCC CGA GAA CCA CAG GTG TAC ACC CTG CCC CCA TCC CGG     1152
Lys Gly Gln Pro Arg Glu Pro Gln Val Tyr Thr Leu Pro Pro Ser Arg
    370                 375                 380
```

```
GAT GAG CTG ACC AAG AAC CAG GTC AGC CTG ACC TGC CTG GTC AAA GGC      1200
Asp Glu Leu Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val Lys Gly
385                 390                 395                 400

TTC TAT CCC AGC GAC ATC GCC GTG GAG TGG GAG AGC AAT GGG CAG CCG      1248
Phe Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gly Gln Pro
                405                 410                 415

GAG AAC AAC TAC AAG ACC ACG CCT CCC GTG CTG GAC TCC GAC GGC TCC      1296
Glu Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp Gly Ser
            420                 425                 430

TTC TTC CTC TAC AGC AAG CTC ACC GTG GAC AAG AGC AGG TGG CAG CAG      1344
Phe Phe Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser Arg Trp Gln Gln
        435                 440                 445

GGG AAC GTC TTC TCA TGC TCC GTG ATG CAT GAG GCT CTG CAC AAC CAC      1392
Gly Asn Val Phe Ser Cys Ser Val Met His Glu Ala Leu His Asn His
    450                 455                 460

TAC ACG CAG AAG AGC CTC TCC CTG TCT CCG GGT AAA TGA                  1431
Tyr Thr Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys  *
465                 470                 475
```

(2) INFORMATION FOR SEQ ID NO:12:

(i) SEQUENCE CHARACTERISTICS:
(A) LENGTH: 477 amino acids
(B) TYPE: amino acid
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:

```
Met Lys His Leu Trp Phe Phe Leu Leu Leu Val Ala Ala Pro Arg Trp
  1               5                  10                  15

Val Leu Ser Gln Val Gln Leu Gln Glu Ser Gly Pro Gly Leu Val Lys
            20                  25                  30

Pro Ser Glu Thr Leu Ser Leu Thr Cys Ala Val Ser Gly Gly Ser Ile
        35                  40                  45

Ser Gly Gly Tyr Gly Trp Gly Trp Ile Arg Gln Pro Pro Gly Lys Gly
    50                  55                  60

Leu Glu Trp Ile Gly Ser Phe Tyr Ser Ser Ser Gly Asn Thr Tyr Tyr
65                  70                  75                  80

Asn Pro Ser Leu Lys Ser Gln Val Thr Ile Ser Thr Asp Thr Ser Lys
                85                  90                  95

Asn Gln Phe Ser Leu Lys Leu Asn Ser Met Thr Ala Ala Asp Thr Ala
            100                 105                 110
```

```
Val Tyr Tyr Cys Val Arg Asp Arg Leu Phe Ser Val Val Gly Met Val
        115                 120                 125

Tyr Asn Asn Trp Phe Asp Val Trp Gly Pro Gly Val Leu Val Thr Val
    130                 135                 140

Ser Ser Ala Ser Thr Lys Gly Pro Ser Val Phe Pro Leu Ala Pro Ser
145                 150                 155                 160

Ser Lys Ser Thr Ser Gly Gly Thr Ala Ala Leu Gly Cys Leu Val Lys
                165                 170                 175

Asp Tyr Phe Pro Glu Pro Val Thr Val Ser Trp Asn Ser Gly Ala Leu
            180                 185                 190

Thr Ser Gly Val His Thr Phe Pro Ala Val Leu Gln Ser Ser Gly Leu
        195                 200                 205

Tyr Ser Leu Ser Ser Val Val Thr Val Pro Ser Ser Ser Leu Gly Thr
    210                 215                 220

Gln Thr Tyr Ile Cys Asn Val Asn His Lys Pro Ser Asn Thr Lys Val
225                 230                 235                 240

Asp Lys Lys Ala Glu Pro Lys Ser Cys Asp Lys Thr His Thr Cys Pro
                245                 250                 255

Pro Cys Pro Ala Pro Glu Leu Leu Gly Gly Pro Ser Val Phe Leu Phe
            260                 265                 270

Pro Pro Lys Pro Lys Asp Thr Leu Met Ile Ser Arg Thr Pro Glu Val
        275                 280                 285

Thr Cys Val Val Val Asp Val Ser His Glu Asp Pro Glu Val Lys Phe
    290                 295                 300

Asn Trp Tyr Val Asp Gly Val Glu Val His Asn Ala Lys Thr Lys Pro
305                 310                 315                 320

Arg Glu Glu Gln Tyr Asn Ser Thr Tyr Arg Val Val Ser Val Leu Thr
                325                 330                 335

Val Leu His Gln Asp Trp Leu Asn Gly Lys Glu Tyr Lys Cys Lys Val
            340                 345                 350

Ser Asn Lys Ala Leu Pro Ala Pro Ile Glu Lys Thr Ile Ser Lys Ala
        355                 360                 365

Lys Gly Gln Pro Arg Glu Pro Gln Val Tyr Thr Leu Pro Pro Ser Arg
    370                 375                 380

Asp Glu Leu Thr Lys Asn Gln Val Ser Leu Thr Cys Leu Val Lys Gly
385                 390                 395                 400

Phe Tyr Pro Ser Asp Ile Ala Val Glu Trp Glu Ser Asn Gly Gln Pro
                405                 410                 415
```

```
Glu Asn Asn Tyr Lys Thr Thr Pro Pro Val Leu Asp Ser Asp Gly Ser
            420                 425                 430

Phe Phe Leu Tyr Ser Lys Leu Thr Val Asp Lys Ser Arg Trp Gln Gln
        435                 440                 445

Gly Asn Val Phe Ser Cys Ser Val Met His Glu Ala Leu His Asn His
    450                 455                 460

Tyr Thr Gln Lys Ser Leu Ser Leu Ser Pro Gly Lys  *
465                 470                 475
```